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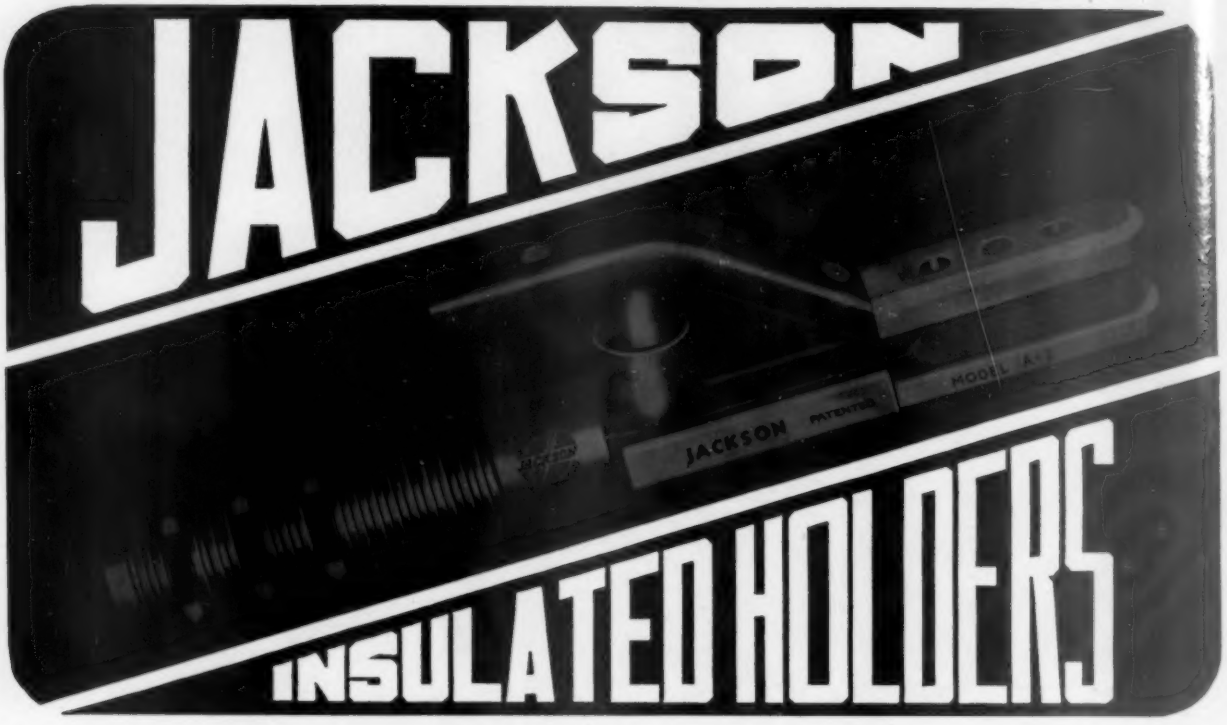
Using Portable Electric Grinder To Finish Welded Joint

JACKSON



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Mechanized Welding

THERE IS AN obvious trend in the direction of mechanized welding to meet the demand for higher production rates. This is particularly true in the automobile industry. Mechanization has been most rapid in resistance welding applications, because the process seems to lend itself readily to automatic control. There is, however, a similar trend noticeable in the application of electric arc and oxy-acetylene processes, although technical developments in the direction of automatic machinery have not been as rapid nor as spectacular as in resistance welding.

We had an opportunity recently to visit a new plant in Detroit, which is devoted to the manufacture of spot welding equipment, particularly the newer types of ultra-speed multiple spot welding machines. This particular company was started in 1935 and is now enjoying a very healthy business despite its youthfulness. Evidently opportunity is not yet dead in this country, at least not in the welding industry.

A word about these new automatic welding machines: They can be compared in their principle of operation with an automobile ignition system, except that in the case of automatic spot welders, the voltage is stepped down approximately in the ratio of 100 to 1 instead of being stepped up to 10,000 or more volts as in the case of an automobile ignition coil. By means of ingenious switching devices, it is possible to make as many as 8 to 10 spot welds per second, or 500 to 600 spots per minute. This is considerably faster than can be done with a manually-operated gun welder.

Undoubtedly there are many who will decry this inevitable trend toward mechanized spot welding. In addition to elimination of semi-skilled labor, this newer equipment may have a tendency to reduce employment considering only the short-term point of view. However, it is useless to attempt to stop the trend toward automatic machinery. As a matter of fact, the machinery industry at the moment, is enjoying the highest degree of activity in its history.

Weldability and Hardenability

MANY OF OUR readers will recognize that these two words are inversely related in their meaning. For example, a steel of high hardenability will obviously have low weldability. Conversely, a steel of low hardenability will have good weldability. At the present time, these widely used words are largely qualitative in their meaning. We are not yet ready to establish definite quantitative values to these words. As a matter of fact, is it necessary to measure exactly the "weldability factor" to the third or fourth decimal? Do we have to know this property as accurately as the electrical resistance of the material? Measuring instruments are available for determining electrical and magnetic properties of materials with a high degree of accuracy. It is only natural, therefore, that engineers seek quantitative data on materials, because engineering is, after all, an exact science.

We think, however, that this "precision complex" can be carried too far. Are not the following definitions sufficiently complete for practical purposes? Dr. Comfort A. Adams has defined weldability as follows: "A piece of steel is said to be weldable when it can pass through the heat cycle of a normal welding process without developing a serious tendency to crack. Practically any steel can be welded, provided there are no restrictions as to preheating, welding technique and postheating. The tendency to crack depends upon two things, the residual stresses of welding and the ability of metal to withstand these stresses without cracking, namely the ductility.

"Both of these factors depend upon the rate of cooling. The higher the rate of cooling, the higher the residual stresses and also the greater the tendency toward a brittle martensitic structure in the heat-affected zone. For each steel there is a critical rate of cooling above which this structure is martensitic (this term is used in a general way to indicate a dangerously brittle condition)."

According to J. H. Critchett, any attempt to define weldability of steels reveals that there is little general agreement as to the exact meaning of the term. The word is sometimes used in a limited sense and sometimes in a very broad sense. It is evident that weldability is dependent upon the method of welding, size and shape of structure, and ability to apply special welding techniques. With proper design and freedom to employ any process, including preheating and postheating, if desired, it is definitely certain that all steels are weldable. With this in mind, Mr. Critchett proposes this definition: "Weldability of steel is that set of properties which permits mechanically continuous surface bonding without undesirable change in the physical properties of the adjacent material." Do we really need a quantitative definition?

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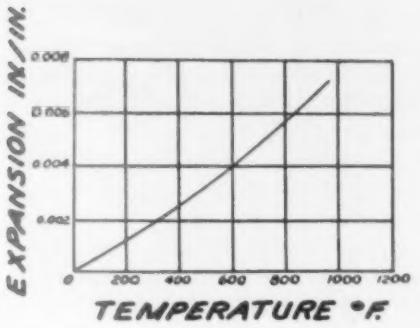


Fig. 1 — Relationship between temperature and thermal expansion of mild steel.

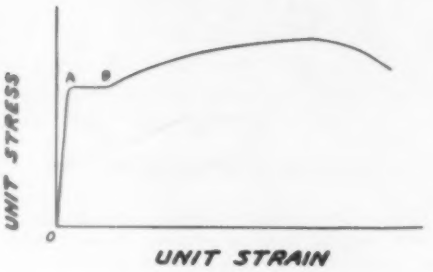


Fig. 2 — A stress-strain curve for mild steel. This graph attempts only to show the general shape.

How thermal stress-relieving

Reduces Residual Stresses

★ A simple presentation of the fundamentals involved in the "orthodox" conception of residual stresses and their reduction by thermal treatment

By HAROLD LAWRENCE*

HEATED ARGUMENTS arise almost every time the subject of residual stresses and their relief by thermal treatment is mentioned. Are there some elements of doubt in this subject that have prevented the elimination of conscientious objectors? Fortunately, there exists a mass of useful scientific information that can be reviewed to shed some light on the perplexing question—"When is thermal stress-relief required?"

Residual stresses occur in welded structures both as the result of contraction of the weld metal and as the result of the expansion and contraction of the base metal due to the heat effect of welding. Since there is a direct relationship between expansion and contraction due to heat and residual stresses, the welding process, as it regards residual stresses, must be studied. In order to keep the problem relatively simple, the physical properties of mild steel only will be studied. Five important physical functions will be considered in their relationship to residual stresses:

1. **Expansion and contraction of mild steel.**
2. **Yield point, or point of plastic flow of mild steel.**
3. **Relationship of thermal expansion and contraction to internal stresses.**
4. **Relationship of yield point to temperature.**
5. **Creep at elevated temperatures.**

As steel is heated, it expands approximately 5/8 in. per 100 deg. F. per 100 ft. of length. The exact figure is 0.00065 in. per inch of length per 100 deg. F. In Fig. 1 is illustrated the relationship between temperature and expansion of mild steel. If we heat an unrestrained piece of mild steel 100 deg. F., the length becomes 1.00065 in. If we raise the temperature of this same piece another 100 deg. F., the length becomes 1.0013 in. Thus, an increase of 200 deg. F. has increased the length of the 1-in. piece of steel 0.0013 in.

Steel is an elastic material within a certain stress range and a plastic material beyond this range. Figure 2 illustrates the stress-strain curve for

*This is the author's pen name. He is a welding engineer and metallurgist for a prominent fabricator of heavy equipment.

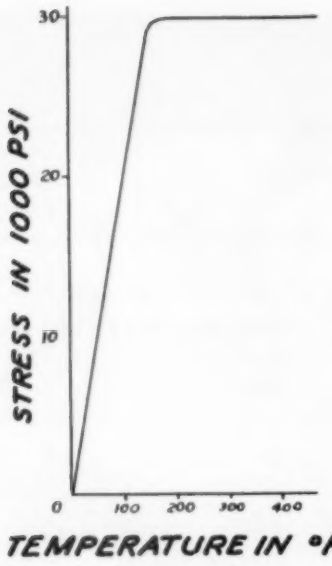


Fig. 3—Comparable degrees of tensile stress and thermal stress to produce identical strain (deformation) in a piece of mild steel.

mild steel. Here the range from O to A is the elastic range, and the horizontal line from A to B is the plastic range that is so important in any consideration of stress relationships. In the elastic range a load of 3000 psi. will increase the length of a 1-in. piece of steel 0.0001 in. Thus increasing the temperature of a piece of steel, increases the length of the piece; and increasing the stress on a piece of steel, increases the length of the piece. Thus, it is easy to see that there is a direct relationship between thermal expansion and contraction, and elongation due to stress. Figure 3 illustrates this relationship.

Temperature Versus Stress

Looking at Fig. 3, it is seen that a rise of 100 deg. F. is equal to an increased stress of 19,500 psi. A rise of 200 deg. F., if the same ratio held true, should produce a stress of 39,000 psi. Actually a rise of 200 deg. F. induces a stress of 30,000 psi., assuming that figure to be the yield point of the steel under study. The difference is represented by the plastic flow of the material, or the horiontal line A-B in Figs. 2 and 3.

Suppose a bar of steel 1 in. x 1 in. x 10 in. is heated slowly and uniformly from 100 to 300 deg. F. on a warm summer day. The piece will be 10.013 in. long. Now let the same piece cool slowly to its original temperature. The bar will now be 10 in. long. At all times during this heating and cooling, the metal is expanding and contracting. Because the bar is unrestrained, the residual stress in the bar is zero. Now the same bar is heated to 300 deg. F. and at that temperature is held firmly at both ends. The length is 10.013 in.; the residual stress is zero. As the rigidly held bar cools to 200 deg. F. the residual stress gradually rises to 19,500 lbs. The length remains the same. The bar continues to cool. At 146 deg. F. the stress reaches 30,000 lbs.; the length is the same; the bar keeps right on cooling. However, the residual stress stops increasing as may be expected from the plastic flow region of Fig. 2, which shows the elongation may be increased without change in residual stress.

From this phenomenon arises the statement made by several welding engineers that the stress in welded structures have not been stress-relieved. For most welded structures are rigid during the welding operation and the temperature difference between cold weld metal and hot weld metal exceeds 200 deg. F., as does the difference between cold base metal and hot base metal. Therefore, residual stresses equal to the yield point of weld metal and base metal exist and should be considered in every weldment. Two principal arguments are raised by the opponents of stress-relieving practice to support their claims: 1. Residual stresses exist in many materials without harmful results. 2. Residual stresses dissipate themselves in a relatively short time. Are these arguments basically sound, or are there some examples that may be contemplated before the arguments are accepted? The latter appears to be the case.

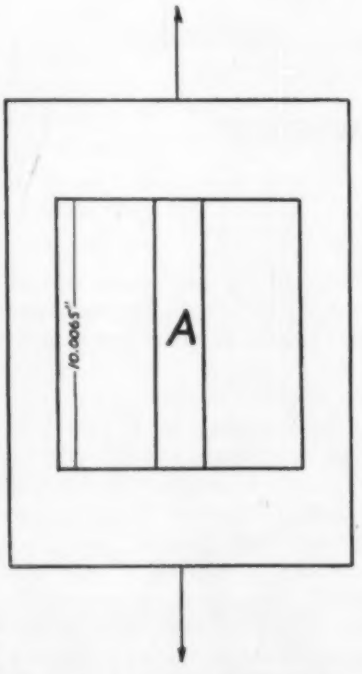


Fig. 4—A schematic diagram used by the author to illustrate the mechanism of mechanical stress-relieving.

Referring to the first argument, the existence of residual stresses in many materials is a well-known fact. All mild steel parts that have been cast, drawn, forged or rolled contain residual stresses. Every mild steel plate and every structural steel shape contains such stresses. Moreover, these stresses may equal the yield point in many cases. In addition, stresses exceeding the elastic limit are impressed upon the stresses already existing in the material by rolling to form pressure vessel shells or by breaking the steel to form machined parts. Neither of these operations appear to affect the mild steel adversely. But these additional stresses may furnish further reasons for stress-relieving, rather than eliminating the advisability of that operation.

The Locomotive Tire

As to the gradual elimination of locked-up stresses in steel by "creep" or some other stress-adjusting mechanism over a relatively short time, this to me seems improbable. The oustanding example of locked-up stress that is used for a particular advantage is the attachment of a locomotive tire to the wheel by shrinking. The only thing that holds the tire on the wheel is locked-up stress. If, as is claimed by those who deny the advisability of stress-relieving, these stresses dissipate themselves, many train schedules would be disrupted by the frequent changing of locomotive tires.

Another claim is that vibration dissipates internal stresses. And again these same locomotive tires are subjected to a great deal of vibration without coming off.

One idea has been advanced that is hard to disprove. A great many pressure vessels and other structures have been built and placed in service without being stress-relieved. These vessels and structures have performed satisfactorily for a long time. This fact is presented as a perfect example of the over-emphasis that has been placed upon stress-relieving.

But there are other instances where failures have occurred which could not be explained on any basis other than

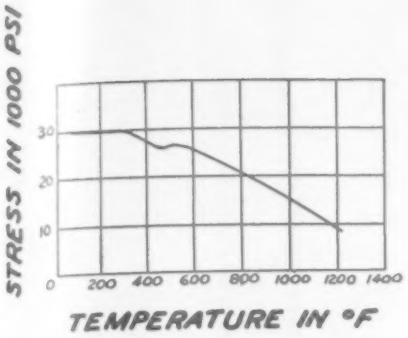


Fig. 5—How the yield point of mild steel is lowered by elevated temperatures. The steel acquires greater plasticity.

that of excessive locked-up stresses. The problem centers itself about the design. Some designs do not allow adequate metal to flow plastically in order to keep the residual stress at the yield point. Ultimate strengths are determined by physical tests that pull the steel to failure. Beyond the plastic range an increase in load results in elongation until rupture occurs. The region beyond the range of plastic flow represents the "no-man's-land" of the designer. So far, no one can tell when the summation of all stresses on a structure takes that structure beyond the region of plastic flow into a region of embrittlement where a small increment of load leads to rupture.

Why Welds Crack

Another approach to the same problem lies in the welding of heavy structures. Here great rigidity restricts the elongation to a very small amount of weld metal. This metal passes through the plastic range and cracks unless thermal treatment or some other means of relieving the locked-up stress is employed. Welds may be left overnight and on examination the following day are found to be cracked. If the welds have not cracked, the claim is made that the residual stresses remaining are not harmful. If the residual stresses were not great enough to cause the metal to elongate almost to the point of rupture, this thought has much merit. However, the existence of an "if" in the problem leads conservative designers to specify stress-relief annealing whenever there is any doubt about the ability of the design to furnish adequate metal for plastic flow protection. As time goes on and more is learned about welding design, fewer structures will undergo a stress-relieving treatment.

In Fig. 4, assume that the bar "A" which is of 1 sq. in. section has been heated to 200 deg. F. and rigidly attached to the frame. The two outside vertical members of the frame are also of one square inch section. When the center bar has cooled 200 deg. F. to the same temperature as the surrounding frame, a tensile stress of 30,000 psi. exists in the bar. This stress is resisted by stresses of 15,000 psi. in compression of the outside members. When a load is placed on the frame in the direction of the arrows, the first thing that happens is the reduction of the compressive stresses in the outer vertical members, accompanied by an increase in the tensile stress of the vertical member "A." Continuing to increase the stress in all three members by increasing the load in the direction of the arrows results in carrying all three members to the yield point where plastic flow takes place. Now the release of the external load restores all three members to a non-stressed condition. This is the mechanism of mechanical stress-relieving.

European Practice

Mechanical stress-relief has been frowned upon by American pressure vessel manufacturers, although European practice has adopted the procedure rather widely. Designers and manufacturers in this country feel that too many places exist in pressure vessels where mechanical stress-relief may be had only at the expense of over-stressing some portion of the weldment that carries only a minor portion of the service load.

As the temperature of mild steel is increased, the yield point decreases as may be observed in Fig. 5. From an original value of 30,000 psi. at ordinary temperatures, the yield point of low carbon steel falls below 10,000 psi. at 1200 deg. The majority of the thermal stress-relief treatments of such steel take place between 1100 deg. F. and 1250 deg. F. The residual stress in the steel falls to the value of the yield point at the maximum temperature. That is true provided that all temperatures are slowly increased and slowly decreased so as not to introduce new residual stresses. Usually this matter is taken care of by the regulatory bodies under whose jurisdiction the work is performed.

"Creep" Is Helpful

Another additional beneficial effect results from the "creep" that takes place at the elevated temperatures to reduce the residual stress to a value below the yield point at the elevated temperature as would be anticipated from Fig. 5. In Fig. 6 is shown the value of the residual stress left in steel structures of varying thicknesses by holding for different periods of time in three distinct temperatures. The selection of the range from 1100 deg. F. to 1250 deg. F. for stress-relieving operations is based upon the effective relief of locked-up stresses, as well as the need for keeping safely below the recrystallization temperature of the steel. Adequate support should be provided for structures during this thermal treatment to prevent sagging and distortion at the elevated temperature.

Preheating and peening may be employed to reduce the intensity of resid-

(Continued on page 23)

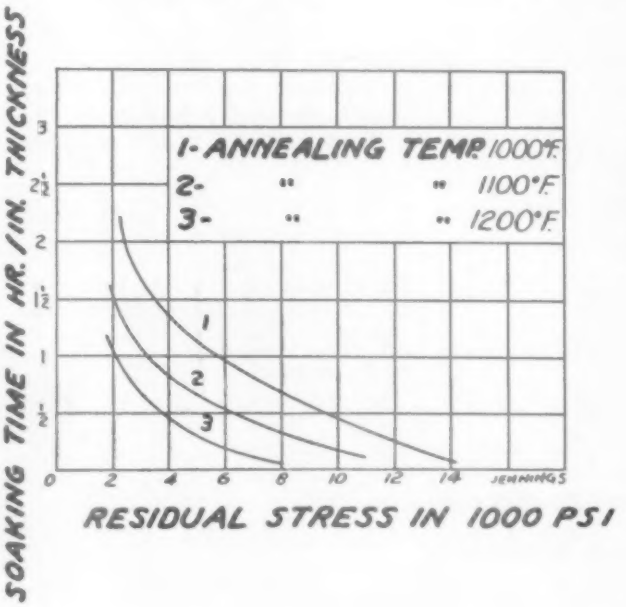


Fig. 6—Estimated residual stresses remaining in steel structures after different degrees of thermal treatment. This chart is credited to Charles H. Jennings of the Westinghouse Research Laboratories.

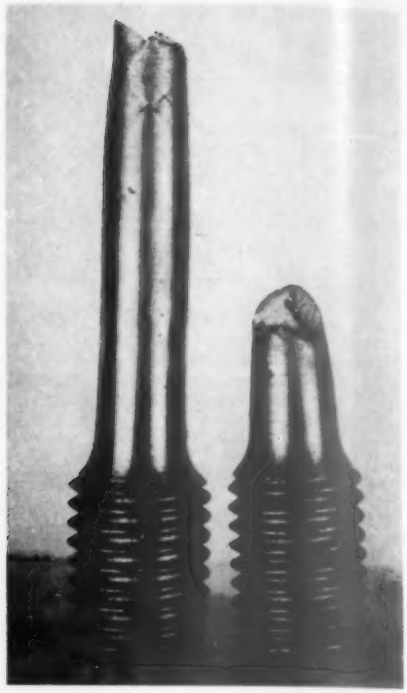


Fig. 1—A fractured weld metal tensile test specimen. Note cavities where fish-eyes occurred near surface of metal.

Laboratory tensile tests shed light on

Fish-Eye Fractures in Weld Metal

By MILDRED FERGUSON
Westinghouse Research Laboratories, East Pittsburgh, Pa.

THE DISTINCTIVE condition identified by the term, "fish-eye fracture," frequently observed in weld metal tensile test pieces, has been investigated microscopically and definite indications of the cause have been revealed. The evidence could not be retained in polished sections without unusually careful polishing technique, so it is not surprising that heretofore it has escaped discovery.

An all-weld tensile test piece which developed typical "fish-eyes" when tested, and with the following properties, was selected for microscopic examination:

Yield Point	Proportional Limit	Ultimate Tensile Strength	Per Cent Elongation	Reduction in Area
41,000	34,500	62,600	26%	38.7%

Macrographs of the fractured test piece showing the cavities identified as "fish-eyes" are shown in Figs. 1 and 2. In the latter they may be recognized by their circular shape, light color and pinhole at the center. Matching faces are both concave showing that the rupture associated with the fish-eyes occurred prior to final separation of the metal which was distinctly along planes of maximum shearing stress. Prior fracture at the fish-eye is also demonstrated by the cavities where fish-eyes occurred near the surface of the metal, Fig. 1. The fish-eye fractures are normal to the direction of maximum stress and therefore represent a failure distinguishable from the final rupture on shearing planes.

A longitudinal section directly through the center of one fish-eye was polished and a deep cavity found where the pin-hole was visible at low magnification, Fig. 3. Note the separation of metal from an inclusion adjacent to the cavity; this separation is in the direction of stress. From examination of this specimen it became very evident that fully-developed fish-eyes, as represented by visible cavities, do not contain the story of their origin.

Accordingly, several sections were

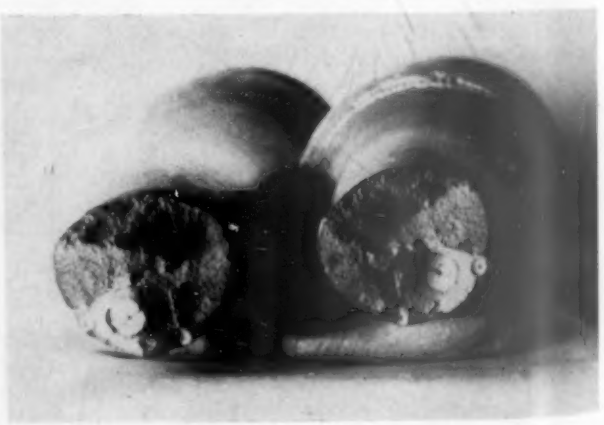


Fig. 2—These fractured specimens show the circular cavities which are identified as "fish-eyes." Note pinhole at center of cavity.

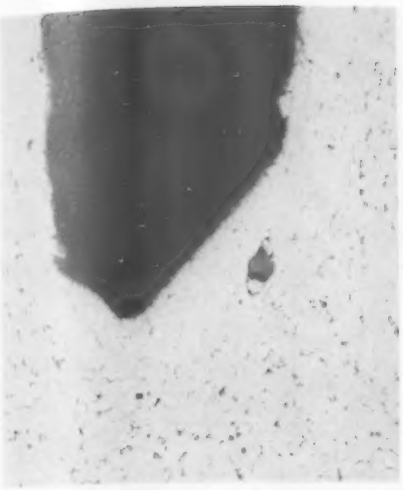


Fig. 3—This deep cavity is a magnification of a longitudinal section directly through the pinhole of a fish-eye cavity.

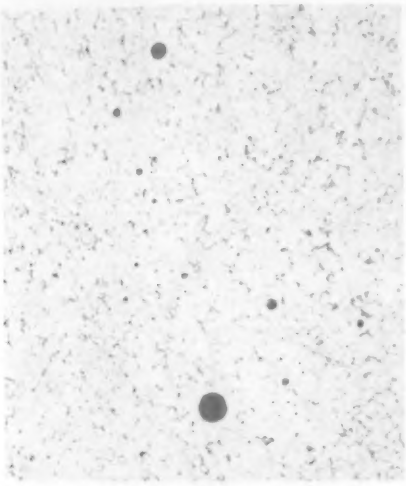


Fig. 4—Small inclusions found in the threaded portion of the test specimen.

cut and polished carefully so as to prevent the ruptured edges of any incipient fish-eyes from wearing away. To accomplish this, paraffin polishing discs and a minimum amount of time were employed.

A summary of the structures observed are shown in the photomicrographs of Fig. 4 to 7. Fig. 4 shows inclusions in the threaded unstrained portion of the test piece. In Figs. 5 and 6 are shown inclusions in the stretched portion of the test piece. Here are represented all stages in the development of a "fish-eye." First there is separation of metal from inclusions in the direction of stress. This longitudinal separation becomes large before the transverse rupture defining the "fish-eye" occurs. In Fig. 6 note also that the inclusion has begun to break up. Fig. 7 represents the near-miraculous! This is very near to a fully developed "fish-eye" with the fractured inclusion as a nucleus apparently suspended in space (it must of course be lightly anchored to the metal in some other plane). It is not difficult to picture a complete fracture through this large crevice forming a "fish-eye" similar to those commonly observed, the pin-hole of the finished rupture being the former seat of an inclusion.

The pertinent features observed relative to this phenomena are as follows:

(1) The dark gray rounded particles which serve as centers of the ruptures known as "fish-eyes" are identified as inclusions in all cases.

(2) The rupture centers are present in layers of all grain sizes within the range of sizes found in this weld which is fairly representative.

(3) A longitudinal separation of metal from the initiating inclusion precedes the transverse rupture that defines a "fish-eye."

Conclusions

Since a "fish-eye" fracture occurs normal to the direction of maximum stress, it must represent a cohesive failure as distinguished from the final failure along shearing planes. It is probable that the "fish-eye" type of fracture due to local weakness in the metal surrounding inclusions is overcome by annealing.

It cannot be seen how the occurrence of "fish-eyes" depends on coarse and fine grained layers of metal or "variation in ductility of multi-layer welds," as suggested by Bela Ronay (*The Welding Engineer*) June, 1939, "Fish-Eyes in Tensile Tests." As mentioned previously, the incipient' "fish-eyes" observed by the writer occurred at random in all grain sizes, wherever inclusions were present. It is possible, however, that the ductility of metal of any grain size in "as welded" material is so low that ruptures form about inclusions readily, and that annealing increases ductility sufficiently to overcome this tendency.

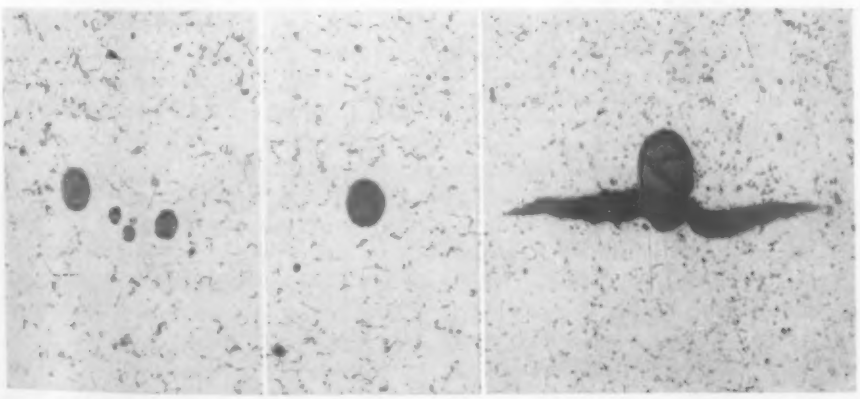
» «

Reducing Residual Stresses

(Continued from page 21)

ual stresses resulting from welding operations. Sequence of welding has an important bearing on the amount of locked-up stresses. Every known influencing factor should be employed in a manner so as to assure the minimum amount of residual stress in any structure.

But as long as any doubt exists as to the detrimental effect of high residual stresses, thermal treatment to relieve these stresses appears to be in order. Since the stress-relieving operation represents a small fraction of the total cost of the finished product, every manufacturer will wish to put that extra amount of quality into his product. Only in that manner can our lack of knowledge as regards the design of welded structures and the exact nature of the stress-relief mechanism be given proper consideration.



Figs. 5, 6—Successive stages in development of a "fish-eye." These small inclusions are in the plastically deformed section of the test piece. Metal first separates in direction of stress. Fig. 7—A real photomicrograph achievement! The transverse rupture has started and the fractured inclusion appears as a nucleus (suspended in the pinhole).

Now Is the Time to Join the

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Bronze welding rods with "low fuming" characteristics are widely used for repair of cast-iron and malleable iron. Photo (American Brass Co.).

Advantages of bronze rods in oxy-acetylene

Welding of Cast-Iron

BRONZE AND OTHER copper alloys have found widespread use as welding rods, principally because the molden metal will alloy instantly with the clean surface of almost any metal which is brought to a cherry red heat. Bronze, originally used for oxy-acetylene welding of cast-iron, malleable iron and semi-steel, is also employed for welding of copper and copper alloys, cast steel, high and low carbon steels, metals of dissimilar composition and, in fact, practically any metal with a melting point higher than the bronze itself.

Bronze welds can be made by the oxy-acetylene method in one-half to one-third the time required to weld with ferrous rods, it is claimed. As extensive preheating is usually unncessary, satisfactory bronze welds can be made by heating the surfaces of the weld area to a red heat only. Thus, bronze welding offers the following economic advantages:

1. **Saving of pre-heating, time and gas.**
2. **Economy and expediency of welding parts in position.**
3. **Reducing possibility of warping or cracking of parts.**
4. **Reducing annealing time.**
5. **Absence of serious stresses after weld is completed.**
6. **Minimum of delay in returning a bronze welded part to service.**
7. **Lower bronze welding temperatures permit faster and more economical joining of intricate sections, parts of radically different weights or cross sections, and metals of different compositions, with a reduction in welding time and a proportionate reduction in gas consumption.**

Preparation and Methods

An important requirement in making sound, strong welds with copper-alloy rods is the proper preparation of parts to be joined. When welding gray or malleable cast-iron with bronze, the edges to be joined should be beveled to make a 60 deg. to 90 deg. V-groove. This is best done by chipping or machining and then sand-blasting the surfaces. The sand-blasting removes the free carbon, thus providing the best adhering surface for the bronze. Grinding should be used only as a last resort, for the reason that a graphite coating is spread over the weld areas by the grinding wheel, thus preventing the bronze from alloying freely with the iron. If grinding must be used, sand-blasting is the best means of removing the graphite coating. Where this cleaning process is not available, the free carbon may be burned off the weld areas by passing the inner cone of the oxy-acetylene flame over these surfaces, allowing the oxygen to unite with the carbon. A little practice will enable the welder to accomplish this "searing" of the carbon without scaling the iron.

Another means of improving the bond between bronze and a cast-iron surface, where other methods are unsatisfactory, and where it is found difficult to "tin" the cast-iron, is to use

This 5,500-lb. forging press was bronze welded in 35 man-hours, using 154 lbs. of rod and 1,078 cu. ft. of oxygen. Photo (American Brass Co.).

an oxidizing agent such as potassium chlorate. Sprinkled liberally on the red hot iron, the chlorate yields oxygen which burns off the carbon, and as soon as the foaming reaction ceases, the normal welding operation can proceed with the usual flux.

In the case of bronze on steel, the edges to be joined are beveled by any convenient means and no special preparation of the contact surfaces is necessary, except to see that they are clean and free from grease and scale.

Position of Work

Experience has shown that the position in which the parts to be welded are placed is of considerable importance. It is not the best practice to set up the work so that the weld is made in a horizontal position. With the parts so positioned, it is difficult to limit the flow of molten metal to the areas which are already heated. The weld metal will invariably flow forward, covering the insufficiently heated weld areas.

This difficulty can be overcome by placing the work so that the weld is made upwards on an incline. In this position the molten metal cannot flow ahead of the heated welding area and the surfaces in advance of the weld are left open to heating. Welders will find by following this method that welds can be made more quickly and will have greater strength than when made horizontally.

In order to obtain sound and homogeneous bronze welds, the use of a good flux is indispensable. There are many satisfactory fluxes on the market and the choice is, therefore, optional. While special fluxes have been devised for the purpose of eliminating

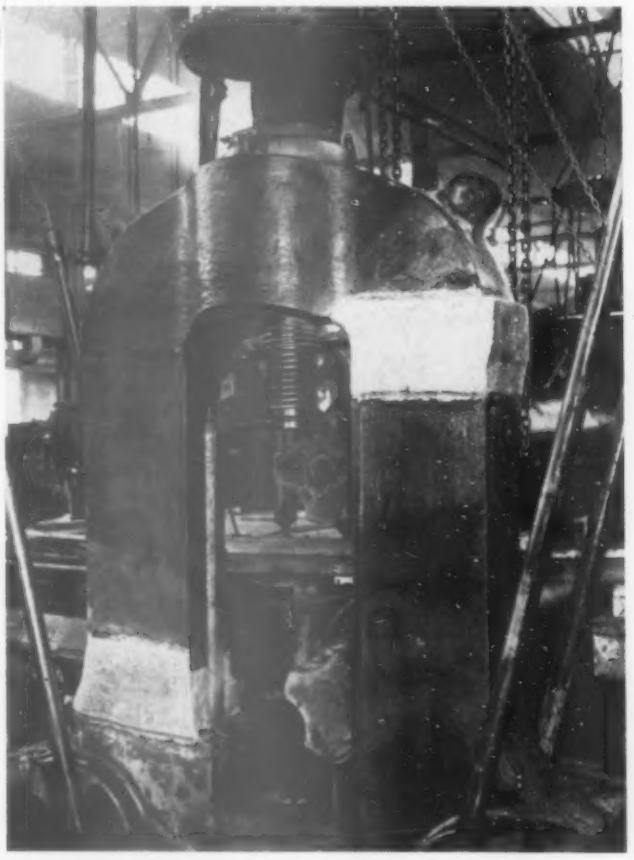
TABLE A—Copper Alloy Welding Rods Suitable for Bronze-Welding of Cast-Iron

Designation.	Alloy Composition.	Suggested Applications.
Bronze A[1]	59% Copper, 5% Zinc, 40.5% Zinc.	Gas welding of cast-iron, malleable cast-iron, copper alloys, nickel alloys and steel.
Bronze B	Copper, Zinc and Tin, amounts not stated.	Gas welding of cast-iron and steel.
Bronze C	60% Copper, 40% Zinc.	Gas welding of cast-iron and miscellaneous steels.
Bronze D[2]	Copper, Zinc, Tin, Iron and Manganese, amounts not stated.	Gas welding of cast-iron, malleable cast-iron, steel, and copper alloys. For wear-resistant surfacing.
Bronze E[3]	(Low Fuming) Composition not stated.	Gas welding of cast-iron, malleable cast-iron, steel, nickel alloys and copper alloys. For wear-resistant surfacing.

(1) A satisfactory alloy for general oxy-acetylene welding, because of its combined high tensile strength, toughness, durability and uniform composition. Bronze A (Tobin Bronze) is adaptable to general repairing of cast and malleable iron, as well as of steel and copper. It is being used in the welding of cylinders and other locomotive parts, automobile engine blocks, cast-iron pipe, machinery parts and similar equipment.

(2) This welding rod (Manganese Bronze) melts at a slightly lower temperature than Bronze A and produces a tough, strong bond which has good resistance to wear. It is well adapted to building up worn bearing surfaces, piston heads and other parts subjected to abrasion and rubbing. This rod is frequently used for salvage repair of malleable iron castings, where the difference in color between the gray casting and the bronze weld is not objectionable. Its low melting point creates a minimum of change in grain structure of the iron.

(3) This low-fuming welding rod (Anaconda 997) is useful for general oxy-acetylene welding. It is a high strength, tough weld metal with low-fuming characteristics, and is used for general repairing of cast and malleable iron, steel and copper. It is effective where repairs must be made quickly and easily on automobile engine blocks, machinery parts and similar equipment. It is also used in building up, by means of the oxy-acetylene torch, corrosion-resisting and wear-resisting surfaces on valves, locomotive drive boxes and machined surfaces.



This 15-ton roll housing (33 in. mill) was repaired at two fractures, using 400 lbs. of ⅝ in. bronze rod. Working in two shifts, the housing repair was completed in 9 days. Photo (American Brass Co.).

carbon from the surface of cast-iron by means of an oxide reaction, experience has shown that this class of flux should be used only for the first "tinning" operation and a good brazing flux employed from this point to the completion of the weld. The use of special carbon-removing fluxes, except for the preliminary or "tinning" coat, is likely to result in porous welds and bonds lacking in strength. When bronze-welding malleable iron, steel, copper, brass, bronze, Monel and similar metals, a brazing flux is all that is needed.

Welding with any of the bronze rods should always be done in the forehand position. Use a neutral to slightly oxidizing flame. Bring the inner cone close to the weld areas, heating a small portion thereof to a cherry red. Then withdraw the flame sufficiently to permit the fluxed end of the bronze rod to be advanced and melted by the outer envelope. Never apply the inner cone directly to the bronze already deposited, nor to the welding rod.

The foregoing procedure has been developed because of the relatively low temperatures at which bronze welding is performed, which necessitates a different method of heat application than when welding with steel or cast-iron rods.

For best results with Bronze A (Table A), the filler rod should be melted and given just enough additional heat to flow freely and take to the preheated base metal. It is advisable to heat the surface of the materials upon which the bronze is to be deposited to temperatures close to the melting points of the welding rod. This is done by quick heating of the preheated metal with the welding torch as the welding advances. Bronze A and the other bronzes in Table A work so rapidly that little or no metallurgical change occurs in the structure of cast-iron or steel.

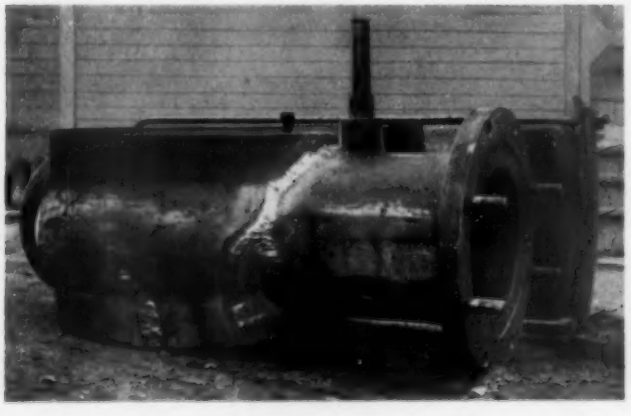
Using a non-ferrous electrode, this operator is making an arc-welded repair on a cast-iron grating. Photo (Wilson Welder & Metals Co.).

Arc Welding of Cast-Iron With Non-Ferrous Electrodes

★ Machinable arc welds in cast-iron were first made back in 1917, when salvage contractors were employed to recondition some of the German merchant ships which had been interred in Eastern ports for the duration of the war. One of these salvage contractors was welding minded and experimented with the idea of using a non-ferrous electrode to weld broken cylinders. It was found that a Monel electrode produced fairly satisfactory welds on cast iron. In 1921 the Wilson Welder & Metals Co., Inc., obtained a patent covering the use of Monel electrodes in making machinable welds in cast-iron. Since this patent expired in August, 1938, several electrode manufacturers have produced a shielded arc Monel electrode for cast-iron welding. Lincoln Electric's "Softweld" is a rod of this type, recommended for machinable welds. Another is International Nickel's No. 130x Monel electrode, regularly used for Monel welding, but now also used for making machinable welds in cast-iron.

When the attempt was first made to weld cast-iron with a mild steel or cast-iron electrode, it was found that welds were not machinable, because of the hard white iron produced at the fusion line. As pointed out in another article*, this extremely hard fusion line can be minimized by proper control of the cooling rate. In the earlier days of welding, however, this condition was not fully understood and accordingly developments were along the line of using a weld metal which did not produce this hard unmachinable zone. Of course, a grinding wheel can be used to finish the surface of such a hard weld layer, but for many applications the welded surface must be machinable. Generally speaking, the property of machinability is a function both of hardness and ductility. Cast-iron is easily machineable when the Brinell hardness is not over 300.

This machinability of arc welded cast-iron was well demonstrated in a locomotive cylinder repair about 20



The bronze welded repair of this 300-lb. engine block was accomplished in 10 hrs., using about 10 lbs. of rod. Photo (American Brass Co.).

*See "Cast-Iron Welding with Cast-Iron Electrodes," by R. J. Franklin, Pages 30-33, February, 1940, issue, The Welding Engineer.

Repairing a cast brake shoe for a Chicago Motor Coach bus. Photo (Lincoln Electric Co.).

years ago. While undergoing general shop repairs, a cracked cylinder was welded with a 5/32 in. Monel electrode. After the weld was completed, the cylinder wall was machined ⅛ in. below the surface with a boring bar. Total cost of this repair job was about $200. This is cited as a good example of cast-iron welding where machinability is definitely necessary.

It is reported that Monel electrodes cannot be deposited overhead satisfactorily for welding cast-iron and for this reason the work preferably should be in the flat position. Vertical welds can be made if the operator is careful. Another important requirement is that Monel should always be deposited on a cold section of cast-iron and not more than a 2-in. length of bead should be deposited at one time. Peening immediately is recommended, using a light hammer to stretch the weld metal to relieve stresses, and to close up whatever heat cracks may develop. With multi-layer welding, peening of each layer is recommended, either by hand or with a pneumatic tool.

In order to insure depositing metal on a cold section of casting, it is recommended that the operator keep moving from one part of the casting to another, or to cease welding until the casting has cooled down. Of necessity, therefore, this is a slow process of welding, but satisfactory results can be obtained. The following current values are recommended for Monel electrodes (on cast-iron):

3/32 in.	50 to 70 amps.
⅛ in.	70 to 100 amps.
5/32 in.	120 to 150 amps.

Excessive temperature gradients are to be avoided, because of inherent weakness and brittleness of cast-iron, and, to this end, two procedures are available, viz: (a) deposit a series of short beads on cold castings and (b) preheat to 500 deg.-1,000 deg. F. and again deposit short beads, to avoid localized hot spots. The latter procedure is preferred because of the lesser tendency to cracking of the cast-iron.

On some welding jobs, a mild steel electrode can be used for the first one or two passes, using a Monel electrode for the finishing pass in order to achieve machinability. This, of course, cuts down the cost of electrodes. Monel flows quite differently than steel weld metal and the operator must accustom himself to its use, by practicing on a piece of scrap.

Patching Pin Holes

Bare nickel wire 3/32 in. diameter is used with the electric arc to patch up small pin holes in cast-iron cylinder walls. The job can be finished with a bearing scraper or small hand grinder. It is said to be a regular production operation in the major automobile plants. A large amount of bare nickel wire is used annually in this application.

American Brass Co. has three flux-coated copper-alloy electrodes available for arc welding of cast-iron. The "Super-Nickel" is a 30% nickel-70% copper rod. The "Ambrac rod is available in two compositions, one containing 30% nickel, 65% copper and 5% zinc. The other "Ambrac" rod has 20% nickel, 75% copper and 5% zinc.

Any discussion of arc welding of cast-iron would be incomplete without mention of the mild steel electrodes which have been used for this purpose for a number of years. It is generally admitted, however, that welds made with these electrodes are not readily machinable. Also, on large castings, it is generally the practice to employ studs in order to increase the mechanical strength of the joint. Austenitic stainless steel electrodes have also been used to weld cast-iron, but an extremely hard fusion zone is developed which is not machinable.

Fabricated Electrodes

We will next describe two types of fabricated arc welding electrodes which have been developed primarily to obtain machinable welds in cast-iron. These electrodes are sold under the trade names of "Nico" and "Copper Arc."

The "Nico" electrode contains nickel, copper, steel and a flux coating, with nickel the predominating element. The use of the steel as an outer sheath for the electrode is said to be a definite advantage, as it makes possible its use as the negative electrode, resulting in smooth flowing, proper fusion and a short arc, which in turn permits welding in different positions.

The weld deposit is soft, fine grained and iron gray in color. When deposited on cast-iron, hardness is not produced either in the deposit or at the line of fusion, according to the manufacturer's claims. Thus the entire weld area is machinable. The tensile strength of welds made with the "Nico" electrode is stated to be equal to that of the best cast-iron. The use of this electrode in cast-iron welding is limited only by considerations of economy. It has been found extremely valuable when one or both of two conditions are to be met, namely: (a) when the entire weld area must be machinable, or (b) when the weld must be of the same

Arc welding a cracked automobile cylinder head. Photo (Lincoln Electric Co.).

This press frame was repaired by "studding" with eleven ¾ in. bolts (3 in. long) and welding ¾ in. boiler plate over the crack, which was about ¼ in. wide and extended across one leg of the press. Photo (Lincoln Electric Co.).

color as cast-iron. Both of these conditions apply to work on new castings and in some cases to repair work.

The "Copper Arc" electrode has a pure copper core with a steel sheath, flux coated. The outer steel sheath permits using the electrode in the negative side of the welding circuit. This promotes better fusion and permits a short arc for welding in all positions.

The weld deposit is a copper-alloy and is of the color of copper. When deposited on cast-iron the deposit is ductile, will withstand shock, can be peened or caulked, and is machinable, except at the line of fusion. The tensile strength of welds made with the Copper Arc electrode is greater than that of cast iron, it is claimed. The conditions under which this rod is applicable for cast-iron welding are: (a) when machinability at the line of fusion is not essential, (b) when the copper color of the deposit is not objectionable; (c) when a malleable deposit that can be peened or caulked is desired, and (d) when economy is a consideration. The cost of "Copper Arc" electrodes is approximately one-half the cost of "Nico" electrodes. Copper Arc electrodes may be used for welding in all positions.

Procedure With "Nico"

To obtain the best results with the "Nico" electrode, the operation should be continuous and the arc should not be broken until the weld is completed or the full length of electrode is consumed. It may not always be possible to follow this procedure, as in the case of light sections which will not stand continuous heat. When the welding operation is stopped for any reason, the arc length should be reduced or choked to diminish the heat prior to interruption of the arc. In general a short arc should be maintained.

This procedure will minimize the possibility of checking during or after cooling. Nickel has a tendency to be brittle at certain temperatures and at these temperatures there is a chance to develop cracks. Nickel also may absorb gases during the welding operation. It is therefore desirable not to hold it at high temperatures longer than necessary. Cold working, such as peening, will aid in relieving stresses and reduce the chances of cracking.

When castings to be welded with "Nico" electrodes are saturated with oil, chemicals, or other materials, they should be heated at the point to be welded to remove gases or other foreign matter, and should be allowed to cool. Then the surfaces should be thoroughly cleaned before welding. Castings which have been in service as combustion chambers on gas or oil engines, or cylinders of chemical pumps are types of castings which should be treated in this way.

In welding cast-iron on which it is difficult to obtain good fusion on cold metal due to the presence of an excess of free carbon and graphite, proceed as follows: First lay a bead along both edges of the fracture. Use low amperage and proceed slowly to facilitate fusion. After these beads have cooled to a point where there is practically no further contraction, a third bead may be laid, uniting the first two and completing the weld.

"Nico" electrodes can be used with a.-c. or d.-c. welding equipment. When used with d.-c. current, the manufacturer recommends that the electrode be used with straight polarity, or electrode negative. The approximate arc currents recommended for different sizes of "Nico" electrodes are:

⅛ in.	75 to 150 amps.
5/32 in.	100 to 200 amps.
3/16 in.	125 to 250 amps.

The wide range of current values is occasioned by the mass and heat capacity of the castings to be welded. In all cases the lowest possible current value for proper fusion, should be used. The deposit of the "Nico" electrodes may be peened or caulked and when multiple layers are deposited, some peening is recommended to relieve contraction stresses after the metal is cool.

Cast-iron to be welded with "Nico" electrodes should be prepared by mechanical means such as grinding or chipping. If the arc or oxy-acetylene torch is used for scarfing or cutting out, the surface may be hard and the weld at the line of fusion may not be machinable. The better the cast iron, the more readily it will machine.

Procedure With "Copper Arc"

Copper Arc electrodes will produce a sound weld on gray-iron castings. The best results are obtained by using the largest electrode that is practical for any given job and with only sufficient heat to obtain fusion. The object of using a large electrode with a minimum of current is to minimize the penetration of the cast-iron to just the degree necessary for thorough fusion and to decrease the amount of cast-iron alloyed with the deposit of the electrode. For instance, the manufacturer recommends the use of a 5/32 in. or a 3/16 in. electrode for welding motor blocks.

If castings welded with Copper Arc electrodes are not clean there may be slight porosity in the weld. Since the deposit of the Copper Arc electrode is soft and ductile, such porosity may be overcome by peening or caulking. As in the case of "Nico" electrodes, if the surfaces to be welded are contaminated with foreign matter, they should

(Continued on page 40)

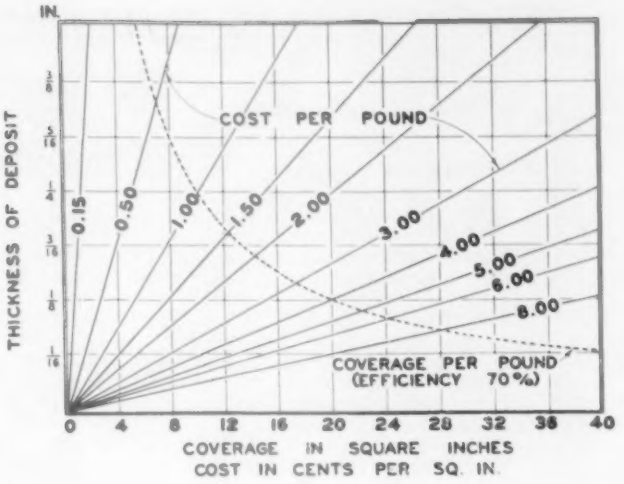


Fig. 18—Approximate coverage per pound of electrode and cost per square inch of deposit for various thicknesses.

Analysis of fundamental factors

Hard-Facing Technique

★ Part 5—Effect of thickness of deposit on wear resistance — Hardness of multiple-bead deposit may be increased by first running a bead of high-carbon steel

By T. B. JEFFERSON*

Engineer, Marine Design Section, Chief of Engineers, War Department, Washington, D. C.

EXPERIENCE HAS PROVED that hard-facing materials will accomplish the purpose for which they are designed, that is, to retard wear. Since a thin coating of hard-facing will reduce wear readily, would not a thicker application reduce the action of wear to even a greater extent? To answer this question a series of tests were designed.

The purpose of this series was to determine the practicability of multiple-bead deposits of hard-facing from the standpoints of: (1) hardness, (2) strength and reliability and (3) economy of application. All of the tests were made using the metallic arc process to deposit either bare or coated hard-facing electrodes. These electrodes were selected from material comprising ferrous alloy groups 1a and 1b and non-ferrous alloy group 2.* The results of these tests are shown in Tables 7, 8 and 9.

The specimens obtained while using bare electrodes for the depositing of multiple beads of hard-facing (Table 7) indicate that a single-bead deposit is harder than a multiple-bead deposit of the same material and, in most cases, the appearance of the single-bead deposit is much better than that of the multiple-bead. The hardness of the original deposit was reduced by the overlaying of a second bead. Deposits of more than two beads had no apparent affect upon the hardness of the deposited material; either towards increasing or decreasing the hardness of the deposit over that obtained from the two bead deposit. A number of these multiple-bead specimens, when ground and polished to a flat surface, exhibited cracks extending throughout the body of the first bead, also numerous blowholes scattered throughout the bead.

The results obtained from the specimens made by depositing coated hard-facing material on the test blocks (Table 8) were consistent with the bare material determinations. Similarly, the multiple-bead specimens exhibited numerous blowholes, cracks and other surface imperfections.

During the Brinell testing of the multiple-bead specimens, both the bare and the coated rod deposits, the imposition of the 3000-kg. load on the 10 mm. ball frequently caused new fissures to form in the specimens. In an attempt to prevent further cracking, additional Brinell tests were made on

*Part 4 of this hard-facing series was published in March, 1940 issue, pages 23-25.

*Refers to author's classification as set forth on page 38, of December, 1939 issue, The Welding Engineer.

TABLE 7—Effects of Multiple-Bead Deposits Upon Hardness (Bare Electrodes)

Specimen No.	Type of Specimen	Number of Beads	Brinell Number 5 mm. Ball 500 Kg. Load	Brinell Number 10 mm. Ball 3000 Kg. Load	Remarks:
301	Single Bead Deposit.....	1	520	601	Ferrous Alloy (Group 1b)
302	Single Bead Deposit.....	1	.....	601	Ferrous Alloy (Group 1b)
303	Single Bead Deposit.....	1	.....	637	Ferrous Alloy (Group 1b)
304	Single Bead Deposit.....	1	.....	514	Ferrous Alloy (Group 1a)
305	Single Bead Deposit.....	1	.....	601	Ferrous Alloy (Group 1a)
306	Single Bead Deposit.....	1	.....	601	Ferrous Alloy (Group 1a)
307	Single Bead Deposit.....	1	520	601	Ferrous Alloy (Group 1a)
308	Single Bead Deposit.....	1	520	601	Ferrous Alloy (Group 1a)
309	Double Bead Deposit.....	2	630	514	Ferrous Alloy (Group 1b)
310	Double Bead Deposit.....	2	630	555	Ferrous Alloy (Group 1b)
311	Double Bead Deposit.....	2	520	461	Ferrous Alloy (Group 1b)
312	Double Bead Deposit.....	2	520	477	Ferrous Alloy (Group 1b)
313	Double Bead Deposit.....	2	.....	578	Ferrous Alloy (Group 1a)
314	Double Bead Deposit.....	2	.....	514	Ferrous Alloy (Group 1a)
315	Double Bead Deposit.....	2	.....	514	Ferrous Alloy (Group 1a)
316	Double Bead Deposit.....	2	.....	578	Ferrous Alloy (Group 1a)
317	Triple Bead Deposit.....	3	630	534	Ferrous Alloy (Group 1b)
318	Triple Bead Deposit.....	3	650	(1)	Ferrous Alloy (Group 1b)
319	Triple Bead Deposit.....	3	630	477	Ferrous Alloy (Group 1b)
320	Triple Bead Deposit.....	3	520	555	Ferrous Alloy (Group 1b)
321	Triple Bead Deposit.....	3	520	495	Ferrous Alloy (Group 1b)

NOTE: Deposits of similar metallurgical properties made with similar rods.
(1) Specimen too porous to test.

some of the specimens using a 5 mm. ball and a load of 500 kg.

The results obtained by the use of the 5 mm. ball and the 10 mm. ball with their different loadings bore out the findings of the investigators[4] of the Bureau of Standards. These investigators found that the Brinell number will vary with the diameter of the ball used, with the indenting load and, in the case of very hard materials, with the type of ball used.

In these tests there was not found a consistent relationship between impressions obtained through use of different size balls. In the case of the bare rod specimens, the Brinell readings obtained using the 5 mm. ball were generally higher than those of the 10 mm. ball, while the reverse appeared to be true for the coated rod specimens. In view of the erratic results obtained when using a 5 mm. ball with a 500-kg. load, it would appear that Brinnell hardness results established by methods other than the A.S.T.M. Standard Brinell Test (10 mm. ball with 3000-kg. load) are likely to be unreliable. These results, however, do indicate that Brinell readings, in general, may be considered unreliable. The concentration of a 3000-kg. load on a 10 mm. ball may cause a shearing at the edges of the indentation, particularily in thin overlays, so that the reading obtained is the resistance to penetration of the hard-facing overlay. Under such circumstances the Brinell reading would be much less than the actual hardness of the overlay.

The hardness of a multiple-bead deposit may be increased materially by first running a bead of high carbon material and then depositing an overlay of hard-facing material on the high carbon deposit. In Table 9 it will be seen that a specimen (No. 505) produced in the aforementioned manner tested 63 Brinell points harder than a single-bead specimen (No. 503) of a ferrous alloy (group 1b) hard-facing electrode. This specimen was also 129 points harder than a double-bead specimen (No. 504) produced with a similar hard-facing electrode.

In general, the results of this series indicate that multiple-bead deposits, obtained by laying one bead of hard-facing over another, until the desired height of deposit is obtained, appear to be weak and unreliable. There is a tendency for hard-facing materials, particularly those producing martensitic deposits, to exhibit characteristics of embrittlement with their high hard-

Table 8—Effects of Multiple Bead Deposits Upon Hardness (Coated Electrodes)

Specimen No.	Type of Specimen	Number of Beads	Brinell Number 5 mm. Ball 500 Kg. Load	Brinell Number 10 mm. Ball 3000 Kg. Load	Remarks:
401	Single Bead Deposit.....	1	520	601	(1) Ferrous alloy hard facing electrode (Group 1b)
402	Single Bead Deposit.....	1	520	*	
403	Single Bead Deposit.....	1	520	601	
404	Single Bead Deposit.....	1	473	653	
405	Single Bead Deposit.....	1	.....	601	(2) Ferrous alloy hard facing electrode (Group 1a)
406	Single Bead Deposit.....	1	.....	601	
407	Single Bead Deposit.....	1	.....	601	
408	Single Bead Deposit.....	1	.....	524	(3) Non-ferrous alloy electrode (high chromium)
409	Single Bead Deposit.....	1	.....	514	
410	Single Bead Deposit.....	1	.....	555	
411	Single Bead Deposit.....	1	.....	454	(4) Ferrous alloy electrode (high manganese)
412	Single Bead Deposit.....	1	.....	461	
413	Single Bead Deposit.....	1	.....	461	
414	Single Bead Deposit.....	1	.....	578	(5) Ferrous alloy hard facing electrode (Group 1b)
415	Single Bead Deposit.....	1	.....	601	
416	Double Bead Deposit.....	2	.....	*	(1)
417	Double Bead Deposit.....	2	.....	*	
418	Double Bead Deposit.....	2	.....	514	(2)
419	Double Bead Deposit.....	2	.....	578	
420	Double Bead Deposit.....	2	.....	555	
421	Double Bead Deposit.....	2	.....	444	(3)
422	Double Bead Deposit.....	2	.....	429	
423	Double Bead Deposit.....	2	.....	444	(4)
424	Double Bead Deposit.....	2	.....	429	
425	Double Bead Deposit.....	2	.....	*	(5)
426	Double Bead Deposit.....	2	.....	*	

*Specimens so marked were too porous to be tested.
NOTE, Deposits bearing similar numbers in remarks were made with similar electrodes.

[4] S. N. Petrenke, W. Ramberg and B. Wilson, July, 1936, "Determination of Brinell Number of Metals," Bureau of Standards Journal of Research, Vol. 17, pages 59-93.

Table 9—Multiple-Bead Deposits (Composite)

Specimen No.	Type of Specimen*	No. of Beads	Brinell Number 3000 Kg. Load 10 mm. Ball**	Remarks:
501	High Carbon Deposit	1	302	Single bead deposit of high carbon (.70 Carbon welding rod on a standard test block.
502	High Carbon Deposit	2	285	Double bead deposit as above.
503	Ferrous Alloy Hard Facing Deposit	1	590	Single bead deposit of Ferrous Alloy (Group 1b) hard facing rod on a standard test block. Martensitic type deposit.
504	Ferrous Alloy Hard Facing Deposit	2	524	Double bead deposit using same type of rod as used for specimen 503.
505	Composite High Carbon-Ferrous Alloy Deposits	2	653	Single bead of Ferrous Alloy (1b) hard facing rod deposited over a single bead of high carbon.
506	Composite High Carbon-Ferrous Alloy Deposit	3	534	Double bead of Ferrous Alloy (1b) hard facing rod deposited over a single bead of high carbon.

*All specimens by metallic arc process.
**10 mm. steel ball used in Brinell tests.

ness. These characteristics are the results of the low ductility usually found in the harder metals.

When hard-facing materials are applied in multiple layers so that the total thickness of deposit is over 3/16 in. there is usually evidence of surface checking of deposited material. This checking is brought about by shrinkage of the hard metal resulting from its expansion by heating during deposition, and its contraction during cooling. The combination of shrinkage and low ductility; that is, the resultant inability of the metallic structure to remain integral, produce numerous cracks.

Surface Cracks

While the appearance of cracks in a hard-facing deposit does not materially affect its hardness, these cracks seriously weaken the cohesiveness of the deposit. This lack of cohesion makes it impossible to predict the probable results to be obtained from such a deposit under service conditions. In some kinds of service the presence of cracks and their resultant deficiency of cohesion may have little or no effect upon life of the hard-facing, while in other applications the presence of cracks will cause the deposit to chip and break loose from the base metal shortly after being placed in service. Likewise, cracks in a hard-faced surface afford an entrance for destructive corrosive agents which might attack the base metal, rendering the hard-facing material ineffective long before the material has completed its expected service life.

Economically it would appear unwise to deposit an overlay of hard-facing greater than that which will give effective service in its probable application. This series of tests indicate that the thickness of the overlay should never exceed the thickness of a single-bead deposit (approximately 3/16 in.). Figure 18 is a graph from which may be determined the coverage per pound and the cost per square inch for various thicknesses of weld deposits, using coated electrodes which range in price from $0.15 to $8.00 per lb. The graph is based on 70% efficiency of deposit, or, on the assumption that during deposition 30% (20% coating and combustible material, 5% splatter and 5% rod ends) of the original weight of rod is lost.

Referring to test specimen No. 504 (Table 9) it will be noted that surface of this specimen was checked and that total thickness of deposit was 5/16 in. The cost per sq. in. for such a deposit, using a ferrous alloy electrode which retails at $2.00 per lb., as determined from Figure 18 is 25½ cents. Using the same graph it is found that the cost of a composite deposit, specimen 505, Table 9, assuming that this 5/16 in. deposit was made up of two beads of equal thickness (both 5/32 in. thick), is $0.14 (High carbon at $0.15 per lb.—.01, Hard-facing at $2.00 per lb—.13) per sq. in. Thus it may be seen that a multiple-bead hard-faced surface, obtained by overlaying hard-facing material on a high carbon deposit is not only 45% cheaper, but 129 Brinell points harder and is free of surface cracks.

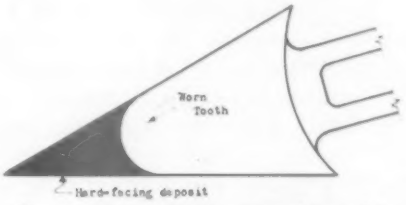


Fig. 19—One method commonly used in reclaiming a worn tooth.

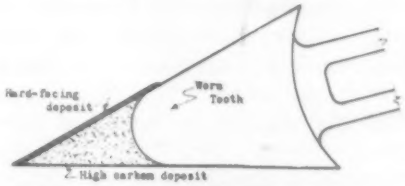


Fig. 20—A more economical method which employs high-carbon steel for building up what has worn away.

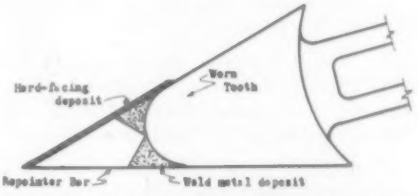


Fig. 21—In this method, most of the worn metal is replaced by a cast steel or manganese-nickel repointer bar which has been welded to the worn tooth.

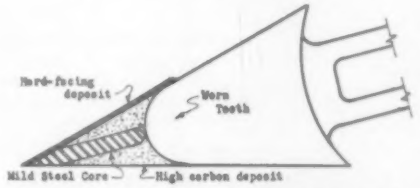


Fig. 22—High-carbon steel is deposited over a mild steel core. Hard-facing is then deposited over the high carbon to increase hardness of deposit.

Dipper Teeth

The teeth of shovel dippers and dragline buckets are probably the most readily reclaimed of the many wearing parts today rebuilt and protected by hard-facing. Always subjected to severe working conditions the teeth of these pieces of equipment are usually worn to such an extent that they can be reclaimed only by a multiple-bead application of welding materials. In Fig. 19 is shown one of the methods commonly used in reclaiming a worn tooth.

This type of rebuilding is quite expensive inasmuch as all of the metal that has been worn from the tooth is replaced by costly hard-facing material. This deposit is likely to be unsatisfactory because it may be broken off due to the low ductility and brittle characteristics of multiple-bead hard-facing deposits. Because of high cost and likelihood of breakage this is not considered a satisfactory method for reclaiming teeth.

The method of rebuilding a tooth shown in Fig. 20 is more satisfactory than that previously described, in that

Fig. 23—How a circular steel filler bar is used in reclaiming dragline track rollers. Worn roller at left is about one inch undersize. Roller at extreme right has been rebuilt and hard-faced.

the metal which has been worn away is replaced with an equally as strong high-carbon material. This reduces the likelihood of loss of replaced metal through breakage; however, this method required too much welding when reclaiming a severely worn tooth to be considered entirely satisfactory for reclamation purposes.

Figures 21 and 22 depict the most acceptable methods for reclaiming teeth. In Fig. 21 most of the worn metal is replaced by a cast steel or manganese-nickel repointer bar which has been welded to the worn tooth. This type of repair results in a strong tooth at a low repair cost. By depositing a high-carbon material over a mild steel core as shown in Fig. 22, the welding cost for reclaiming the tooth is also kept down. This method is advantageous in that it makes possible the deposition of hard-facing materials over high-carbon to increase hardness of deposit. All of the rebuilding methods outlined are for steel teeth repaired with steel. If the teeth are manganese steel they should be rebuilt with a manganese alloy or "tinned" with stainless steel before attempting to apply a steel welding material to them.

Figure 23 illustrates the progressive steps in reclaiming dragline track rollers. The worn roller on the left is approximately one inch undersize. Rather than depositing multiple beads of weld metal the reclamation is expedited by use of a steel filler bar as may be seen on the center roller. The right hand roller has been completely reconditioned by welding and hard-facing.

In rebuilding of crusher jaws such as those shown in Fig. 24, the use of an applicator bar is superior to multiple-bead deposits. To attempt to rebuild such a part by depositing multiple beads of hard-facing material would probably result in not only an expensive, weak and unreliable repair, but also a warped crusher jaw. When a manganese-nickel bar is used to rebuild a manganese crusher jaw very little welding is necessary. The bar is merely welded in place, then coated with hard-facing and the job is complete.

Conclusions

The conclusions drawn from this series of tests are:

1. Single-bead deposits of hard-facing produce the hardest surfaces.

2. Probable service life of a multiple-bead hard-facing deposit is unpredictable, because of surface cracks and other imperfections found in this type of deposit.

3. Multiple-bead hard-facing deposits of a composite nature; i.e., a deposit formed by overlaying hard-facing material on a high-carbon deposit, are the most economical when multiple-bead deposits are required to obtain desired thickness of deposit.

4. A multiple-bead composite deposit of hard-facing produces a harder deposit than can be obtained from a single-bead hard-facing deposit.

5. The application of hard-facing over applicator or filler bars is the fastest and often the most economical means of replacing large quantities of worn metal.

(The sixth and concluding article of this series will discuss relationship between hardness and resistance to abrasive wear.)

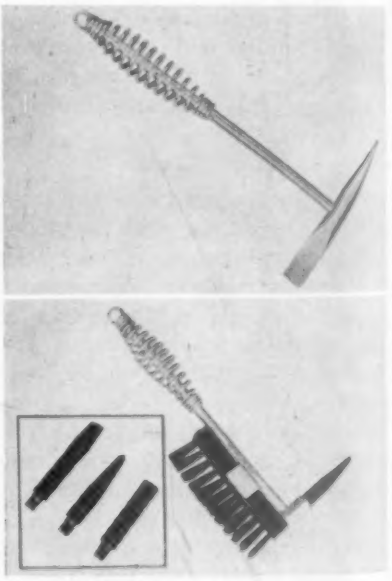
Fig. 24—Applicator bars are superior to multiple-bead deposits in rebuilding of crusher jaws

» «

Two Weld Cleaning Tools

★ The Atlas Welding Accessories Co., 307 Boulevard Building, Detroit, Mich., announce production of a line of weld cleaning tools. These consists of the "Atlas Tomahawk," which is a chipping hammer for removing slag from welds, and the "Atlas Weld Cleaning Tool," which is a combination chipping hammer and wire brush. The weld cleaning tool has removable tool steel bits which can be furnished in various type points, which are threaded and screwed into the head. The brushes can also be replaced.

Both tools are of all metal design, to withstand heat of welding and rough use. The flexible steel handle is designed to resist shock transmitted to the hand and insures a positive grip. These tools will be sold through welding supply houses.



Above—"Atlas" chipping hammer. Below—"Atlas" weld cleaning tool.

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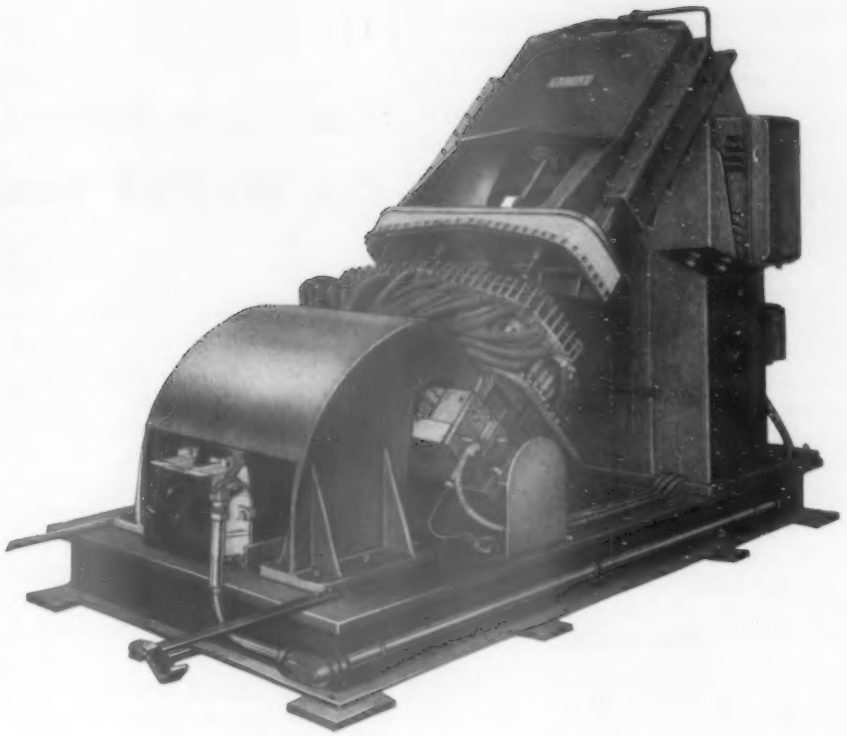


Press type of spot welder to weld windshield reinforcements to roof section with 68 spots. All spots invisible on outside of roof section.

Description of

ultra-speed method of

Multiple Spot Welding

MODERN MANUFACRURING requirements demand modern production methods; hence the creation of the ultra-speed method which has been found adaptable to many multiple spot welding applications. Fundamentally, an ultra-speed welder is a machine for the rapid assembly of sheet metal parts by the spot welding method. In addition to incorporating many features of other type multiple spot welders, ultra-speed welders have several advantages not contained in other machines doing similar work.

External jigs and clamping fixtures are eliminated where ultra-speed welders are used. The position of the welding electrodes and the shape of the lower die takes the place of any such external equipment; thus reducing and maintenance costs. Since an assembly does not require any movement after being placed in the machine, it can be welded with a single pass of the contact roll. This feature removes practically all time between welds. The time per welded assembly necessarily changes; however, the amazing speed of 20 spots per second is entirely possible. Several hundred electrodes may be incorporated in a single machine, making the number of spot welds practically unlimited.

The movable portion of the secondary circuit is usually actuated by hydraulic or mechanical operation. In any case, the movement is rather gentle, entirely eliminating the impact of electrodes on the work,which, in turn, materially increases electrode life. When the secondary circuit is in position, the welding pressure is determined by an adjustable pressure arrangement on the individual electrodes. It is common practice to use spring adjustments, although a few machines have incorporated, at increased cost, an air cylinder on each electrode.

As the two halves of the secondary circuit are brought together with the material to be welded in place, irregularities in the pieces are overcome at the electrode points; thus, the material is held stationary in the desired position before any current is applied. After the contact roll has travelled the length of the segment bar, the welds are allowed to cool under the welding pressure. There is an advantage in cooling a weld under the same pressure that forged the molten metal together. Ultra-speed welders incorporate this feature which results in consistently better and stronger welds.

From the sketch, (Fig. 1), it is evident that a single weld takes place during one position of the contact roll as it travels across the segment bar. If one could disregard secondary loops, variable distances between electrodes and transformers, losses due to the several contact points, and speed of operation, transformer capacities could be comparable to a single spot welder. Although the above factors must be

This article was prepared under direction of the Publicity Committee, Resistance Welder Manufacturers' Association.

considered, the ultra-speed method of successive spot welds does not require excessively large transformers. It is common practice to use 50 kva. or 75 kva. transformers, singly or, if the work becomes decentralized, in multiple.

Control of Current

During the movement of the contact roll as it passes across the segment bar, the flow of current must be stopped as the roll passes from segment to segment. If the current flow is not broken, arcing and burning occurs at the roll. Since this must be compensated for and some accurate method of timing each weld is necessary, both have been incorporated into a cam on each segment bar and a limit switch attached to the contact roll.

Limit Switch

As the roll passes across a single segment, the limit switch is depressed by the cam and current flows for an adjustable predetermined time. As the end of the individual segment bar is reached, current flow is stopped until the next bar is in contact with the roll. When the roll reaches the end of the segment bar, another switch is engaged which applies a brake to the motor driving the contact roll and reverses the motor leads so that the next weld is accomplished with the contact roll travelling in the opposite direction from the preceding weld.

Conclusion

The foregoing presents a brief description of the operation of an ultra-speed welder and presents a few advantages such a machine has over other types of equipment doing similar work. Although ultra-speed welders are comparatively new in the resistance welding field, their quiet and rapid operation has already been the solution to many spot welding problems.

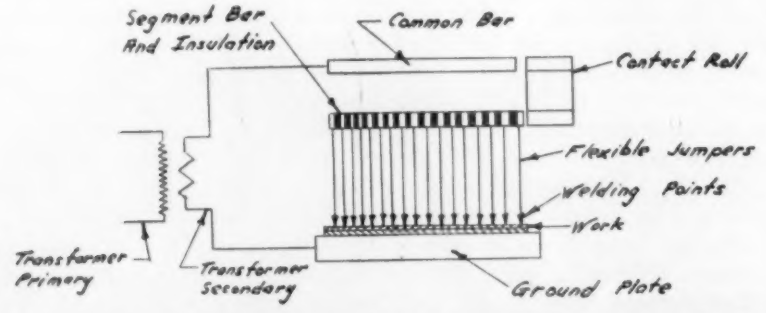


Fig. 1—Schematic circuit sketch to show how the heavy welding current is distributed from segment to segment as the contact roll travels across the segmented bar.

Tentative Recommended Standards For Welded Structural Connections

★ In 1938 the board of directors of the American Institute of Steel Construction, 101 Park Ave., New York City, appointed a committee to formulate a statement of fundamental principles, minimum requirements, and recommendations for multi-story buildings.

After careful study this committee concluded that the subject is not yet sufficiently stabilized to justify issuing complete standard details at this time, but it did develop certain tentative minimum requirements and recommended tentative typical details. The committee is proceeding with its work and will later issue more complete information on minimum requirements and standard details.

Tentative Minimum Requirements

The American Institute of Steel Construction's standards for welded connections shall permit use of heavily-coated electrodes only. Unit stresses in welds shall not exceed those permitted, for welds made with heavily-coated electrodes, by the A.W.S. Code for "Fusion Welding in Building Construction." The other requirements of that code shall be complied with as a minimum.

Flexibility of Connections

In welded construction the question of rigidity or flexibility of connections shall be determined by the designer and not detailer. The designer should determine whether connections are to be rigid or flexible and indicate this on design drawings, preferably by sketches.

Except as otherwise indicated by designer, all connections shall be designed as flexible. Flexible beam connections shall permit ends of beam to rotate sufficiently to accommodate its deflection by providing for a horizontal displacement of top flange as determined by following formula:

$$e = \frac{S \times L}{3{,}625{,}000}$$

where e = horizontal displacement between top and bottom of beam at its end (in.).

S = flexural unit stress in beam at mid-span (psi.).

L = span of beam (ft.).

Various methods for providing flexibility in beam connections are illus-

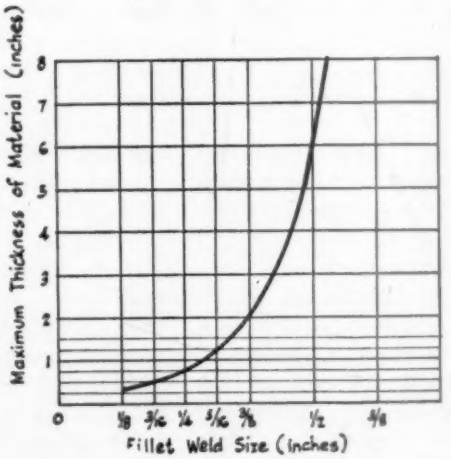


Fig. 1 — Relation between fillet weld size and maximum thickness of section on which various fillet sizes may be used.

Fillet Weld Size	Max. Thickness of Mat'l.
1/8	5/16
3/16	1/2
1/4	3/4
5/16	1 1/4
3/8	2
1/2	4
5/8	Over 4

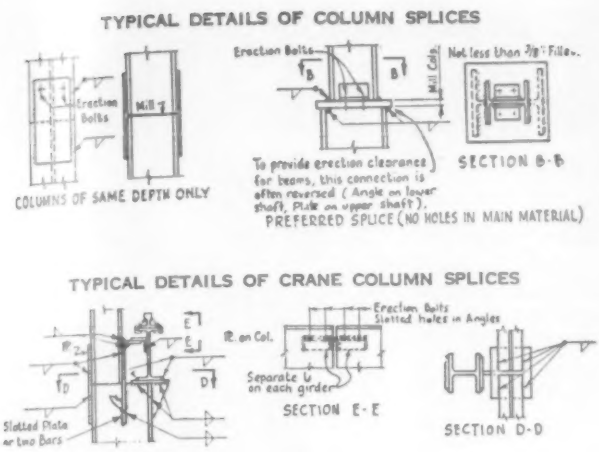

TYPICAL DETAILS OF COLUMN SPLICES
Erection Bolts
Mill
COLUMNS OF SAME DEPTH ONLY
Erection Bolts
Mill Cuts
Not less than 3/8" Fillet
SECTION B-B
To provide erection clearance for beams, this connection is often reversed (Angle on lower shaft, Plate on upper shaft).
PREFERRED SPLICE (NO HOLES IN MAIN MATERIAL)
TYPICAL DETAILS OF CRANE COLUMN SPLICES
R. on Col.
Erection Bolts
Slotted holes in Angles
Separate R on each girder
SECTION E-E
Slotted Plate or two Bars
SECTION D-D

Fig. 2—Typical details of column splices, for columns of same depth (left) and for columns of dissimilar depth (right). Also crane column splices (lower left).

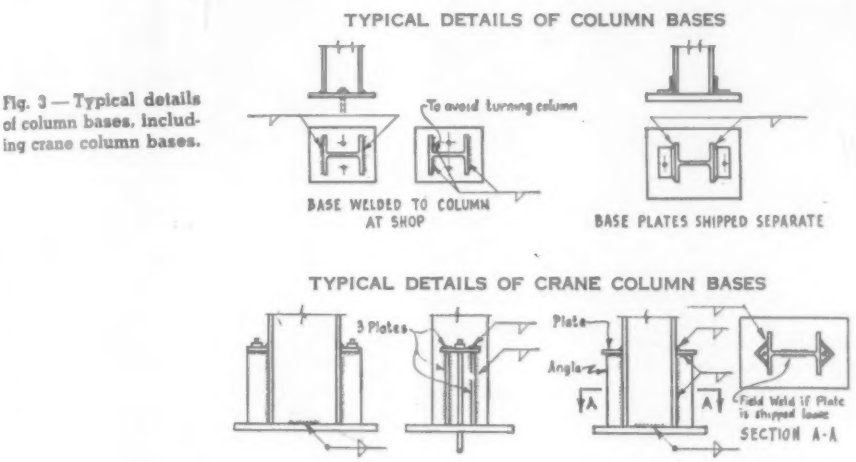


Fig. 3—Typical details of column bases, including crane column bases.

trated in the sketches of typical details.

Special care is necessary when welding at temperatures below 25 deg. F. in order to avoid poor workmanship, undue chilling, large residual stresses, and possible cracking. Advisable precautions are protection of operations from strong winds, local preheating of base metal, and protection of work from too rapid cooling.

Fillet Weld Sizes

Chart in Fig. 1 shows relation between fillet weld size and maximum thickness of material on which various sizes of weld may be used. (The greatest thickness of material connected by a fillet weld determines minimum size of weld which may be used.)

The size of fillet welds should be selected with regard to inherent efficiency of small welds, necessity of making connections in small space limitations of welding technique. Practical evaluation of these factors has established the ¼ in. and the 5/16 in. fillet welds as standard sizes for structural welding. Fillet welds smaller than ¼ in. and 5/16 in. are often economical or otherwise desirable and they may be used, subject to the restrictions of the chart and table (Fig. 1).

The use of the fusion welding process (sometimes electric arc, sometimes oxy-acetylene) plays an increasing part in fabrication of structural steel.

(a) As an aid to shop assembling processes ("tack-welding");

(b) As the final method of joining parts for transfer of stresses, in shop or field ("strength-welding").

The art of designing and detailing for safe and economical employment of strength-welding is a relatively new and changing one; the economy of a welded structure as compared with a riveted or riveted-and-bolted one, is as yet a subject not for general statements but for estimate of the individual case. The A.I.S.C. Manual Committee reserves for future editions of this Manual the possibility of publishing tabular data and recommendations for practice in the field of strength-welding.

A.W.S. Code

At present, it suggests that strength-welding of structures be permitted only on condition that the designing, detailing and erection are in the hands of personnel well trained in best practice of the art. It considers the best exposition of that art is to be found in the reports and recommendations of the American Welding Society, 33 West 39th St., New York City. The "Code for Fusion Welding and Gas Cutting in Building Construction" of that society, is authoritative with respect to materials, technique and specifications for design.

For convenience, the section on permissible unit stresses for welded connections, as established by the A.W.S. Code, is appended:

"(1) Welded joints shall be proportioned so that the stresses caused therein

(Continued on page 38)

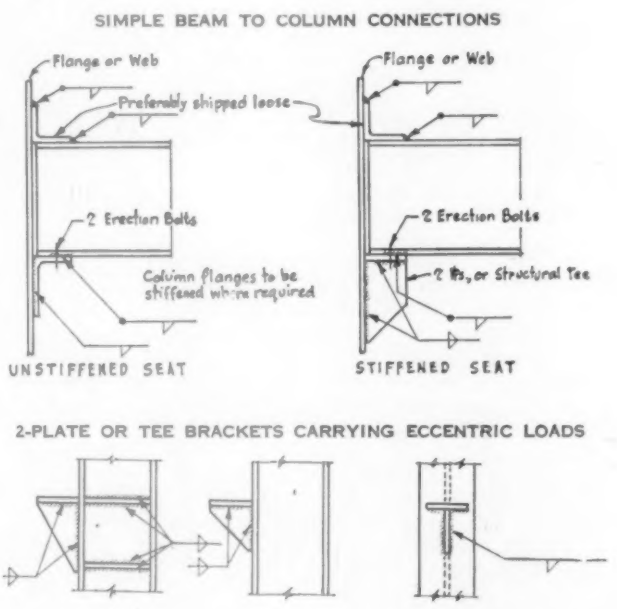


Fig. 4—Simple beam-to-column connections and welded brackets for carrying eccentric loads.

New Product Developments

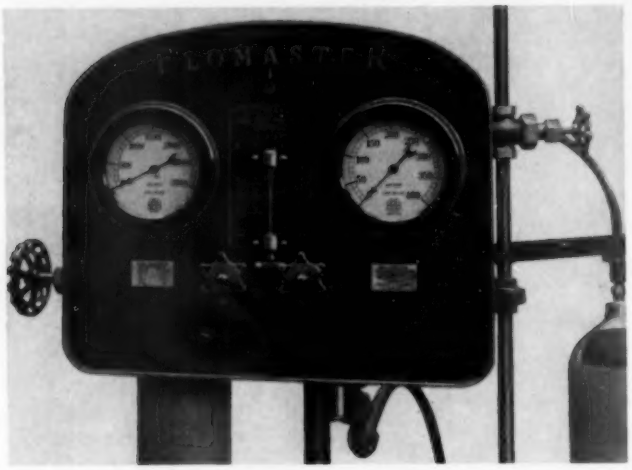


Fig. 1 — Instrument panel contains pressure gauges, flow indicator, and the two principal controls.

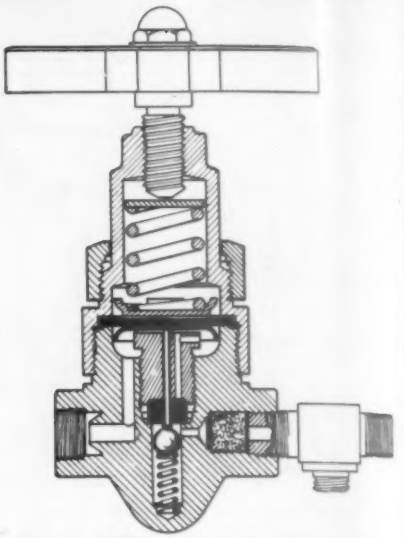


Fig. 3—Performance of flow controller is largely governed by the design of pilot regulator. Adjusting handwheel for this pilot regulator is shown on instrument panel (Fig. 1).

Airco Develops Heavy-Duty Oxygen Flow Controller

★ The Airco "Flomaster" is claimed to be the world's largest oxygen flow controller. It has been designed specifically for installations requiring large volumes of oxygen and in which the oxygen is stored in large banks of cylinders or in special containers at pressures as high as 2500 psi. It has a discharge capacity up to 60,000 cu. ft. of oxygen per hour and will deliver a pressure which may be adjusted anywhere from 0 to 200 psi. It is designed for high precision pressure regulation and is said to be independent of variations in demand rate and of variations of inlet pressure as the storage bank is drained from 2500 lb. down to its terminal value.

In order that the flow indicator may be reasonably precise and yet cover a wide range of flows, a flow-range selector had been provided which by controlling the size of a by-pass orifice will render the flow indicator specifically adaptable for any one of four different overlapping flow ranges.

The delivery pressure of the controller is governed by a pilot regulator, which discharges gas directly into the control dome, bolted over diaphragm of main regulator. In order that delivery pressure of regulator may remain unaffected by room temperature, and also in order to accommodate conditions brought about by sudden changes in inlet pressures, such as occur when controller is connected to a fresh storage bank, a diffuser block has been provided which is in communication with control dome master regulator, so that there is a continual discharge of oxygen from control dome to atmosphere. This feature also renders the flow controller immune to minor variations in closure pressures required in pilot regulating valve.

The main regulator body is fitted with a ½-in. relief valve. In addition, a 3-in. bursting disc has been provided which is sufficient to avoid excessive pressure in regulator body, even if master regulating valve seat has been inadvertently omitted and 2500-lb. pressure suddenly admitted into regulator by opening intake valve.

When pressures of 2500 lb. are suddenly admitted into a reducing valve, the gas initially in high-pressure passages of valve is compressed so that exceedingly high temperatures may develop. Because high temperatures in vicinity of regulator valve seat and in presence of oxygen, are undesirable, a dead-end chamber has been piped to filter cavity immediately below regulator nozzle. With such an arrangement, the hot gas is pushed into dead-end chamber, while cold gas flowing from storage bank will be brought in contact with the seat.

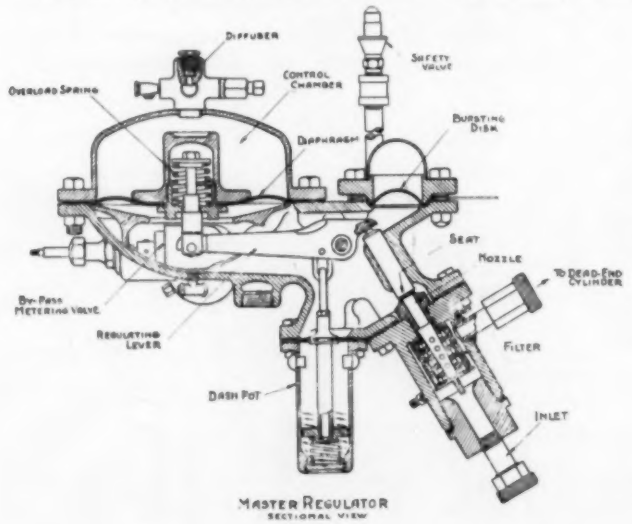


Fig. 2—Sectional view of the master regulator. The pilot regulator discharges gas directly into control dome, which is bolted over diaphragm of main regulator.

» «

Two New Lincoln Hard-Facing Electrodes

★ The Lincoln Electric Co., Cleveland, Ohio, announces two new hard-facing electrodes which will be known as "Faceweld No. 1" and "Faceweld No. 12." These electrodes are cast abrasion-resisting alloys used for hard-facing by the metallic arc process. Both are coated electrodes, have exceptionally good arc characteristics and produce a smooth dense deposit. Deposits are resistant to abrasion, but not excessively hard and brittle. "Faceweld" bonds well with all types of ferrous alloys.

"Faceweld No. 1" is a general-purpose hard-facing electrode and is the softer and tougher of the "Facewelds." It has good abrasion resistance and high resistance to impact for this class of material. "Faceweld No. 1" is used for surfacing such parts as digger teeth, scarifiers, grader blades, cement plant machinery, etc. by arc welding.

"Faceweld No. 12" is applied by arc welding and is somewhat harder than "Faceweld No. 1" and has superior resistance to abrasion. Its resistance to impact is excellent for this type of material, but not quite as high as "Faceweld No. 1" in this respect. Applications include screw

conveyors, conveyor sleeves, plows, gyratory crushers, power shovel and dragline bucket parts, dredge pump impellors and casings, coal pulverizers, jaws, cement mill machinery, such as Bradley and Griffin rings, crusher roll plates, etc.

The hardness of these electrodes will vary somewhat depending upon conditions under which they are deposited, but in general will be within the range shown herewith. As they show practically their full hardness in the as-deposited state, heat treatment does not materially affect their hardness.

"Faceweld No. 1" Hardness:

Single-layer hardness—approx. 45 to 52 Rockwell C.

Multiple-layer hardness—approx. 52 to 58 Rockwell C.

"Faceweld No. 12" Hardness:

Single-layer hardness—approx. 52 to 57 Rockwell C.

Multiple-layer hardness—approx. 55 to 59 Rockwell C.

"Faceweld" either No. 1 or No. 12 is furnished in ¼ in. size—12 in. long and comes packed in 5-lb. and 10-lb. containers.

» «

Multiple-Speed Flexible Shaft Grinding and Polishing Unit

★ A multi-speed flexible shaft machine, an addition to the Junior line of Stow Manufacturing Co., Inc., Binghamton, N. Y., is suited for grinding, drilling, polishing, wire scratch-brush work and many other similar applications. This new Stow Junior tool is a utility machine which consists of motor with extension cord and plug for any 115-volt light socket, mounted on a four-caster base which gives it a low center of gravity. It is also equipped with an adjustable arm for regulating belt tension, a three-step cone pulley, a "V"-belt and a flexible shaft with clamp spindle.

This Stow model offers a choice of either ¼ hp. or ⅓ hp. motor, and a speed range of from 875 to 3,500 r.p.m. Shaft sizes are ⅜ in. by 5 ft. for the ¼ hp. unit and ½ in. by 6 ft. for the ⅓ hp. unit, with a maximum wheel capacity of 6 in. by 1 in. and a drill capacity up to ⅜ in.

Stow Junior flexible shaft unit.

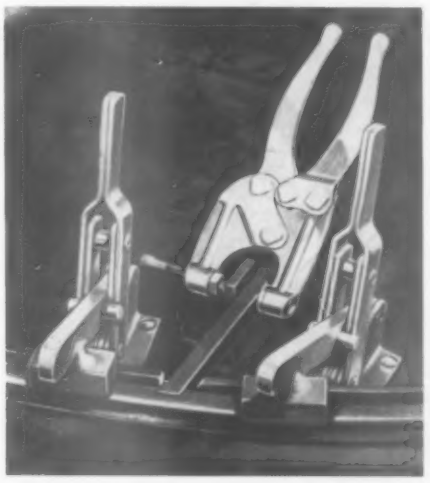
» «

Welding Rod Holder

★ This rod is designed to hold cast-iron welding rods, 3/16 to ⅜ in. diameter. It has three positions in the jaw. The 20 deg. groove is the most commonly used. A rod can be picked from the table with the use of only one hand by pushing the holder over the rod and then pulling the trigger and lock, which is in front of the trigger. The operator should catch the rod near its middle and as the rod is used turn the holder upside-down and hit the rod on the table to slide it to a balance position. When the rod is used to within ¼ in. of the holder, trip the lock and drop the stub. Further details can be obtained from the manufacturer, C. M. Miller Co., Madison, Ind.

Holder for cast-iron welding rod.

» «



How toggle clamp and toggle pliers are used to secure positive alignment of members.

Two New Clamping Tools

★ Detroit Stamping Co., Detroit, Mich., has developed two new clamping tools, both of which are especially suitable for use in the aircraft industry; also for clamping and holding other types of work in production, where limited clamping space renders larger size clamps unusable.

Rapid action De-Sta-Co Toggle Clamp No. 220, "Aviation" model, of which there are two shown in the illustration, measures but 1-29/32 in. by 1⅝ in .at base, well proportioned throughout and especially engineered for quick clamping, positive holding and instant release. Raising of operating handle delivers a pressure ratio of 33 to 1 to clamping arm.

Rapid action De-Sta-Co Toggle Pliers No. 460, "Light Duty" model, as shown in center of illustration, measures but 6-15/32 in. long overall. Lock nut allows for rapid adjustment of damping head from 0 to 11/16 in. spacing, so as to accommodate varied thicknesses of work. Closing of handles exerts a pressure ratio of 75 to 1 at clamping or biting end.

» «

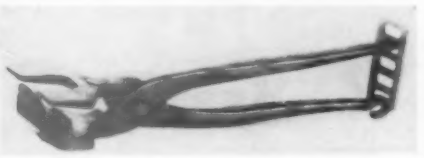
Jackson Introduces a Folding Eyeshield

★ A new type of eyeshield characterized by its lightness, comfort and low cost, is announced by Jackson Electrode Holder Co., Detroit, Mich. It is recommended particularly for workmen engaged in buffing, polishing and light grinding operations, woodworking, and for helpers around spot, flash and gun welding machines.

Jackson folding eyeshield.

The shield fits the face snugly and comfortably, provides complete eye protection, and does not interfere with prescription glasses. Wide vision in all directions is afforded through lenses of flexible shatter-proof Plastacele. Ventilation is provided through screened grommets. The shield folds flat, fits the vest pocket.

» «



Simple alignment clamp to aid in sheet metal welding.

Handy Alignment Clamp

★ Wilkes-Barre Welding Co., Wilkes-Barre, Pa., has developed a simple hand clamp, somewhat similar in appearance to a hand pliers, to assist the welder on sheet metal jobs. It is recommended for use in welding automobile fenders, small tanks and containers and for general sheet metal work. The parts are held in proper alignment before welding. An adjustable clamp slips over the handles to lock them securely in place, after the clamp is properly positioned. It is claimed that with the aid of this clamp, the work will not buckle or warp.

Welded Structural Details

(Continued from page 35)

by loads specified in the Building Code shall not exceed the following values, expressed in kips (thousands of pounds) per sq. in.:

Maximum Working Stresses

Kind of Stress	For Welds Made with Filler Metal of Grade 2, 4, 10 or 15	Grade 20, 30 or 40
Shear on section through weld throat	13.6	11.3
Tension on section through weld throat	15.6	13.0
Compression (crushing) on section through throat of butt weld	18.0	18.0

"Fiber stresses due to bending shall not exceed the values prescribed above for tension and compression, respectively. Stress in a fillet weld shall be considered as shear, for any direction of the applied stress.

(2) In designing welded joints, adequate provision shall be made for bending stresses due to eccentricity, if any, in the disposition of base-metal parts."

Committee Personnel

The A.I.S.C. committee in charge of this work consists of **E. T. Blix,** chief engineer, Mississippi Valley Structural Steel Co.; **William F. Carson,** consulting engineer; **Donald Derickson,** professor of civil engineering, Tulane University; **F. H. Dill,** American Bridge Co.; **James L. Edwards,** H. G. Balcom Associates, consulting engineers; **C. F. Goodrich,** chief engineer, American Bridge Co.; **T. R. Higgins,** district engineer, American Institute of Steel Construction; **Jonathan Jones,** chief engineer, Bethlehem Steel Co.; **Verne O. McClurg,** chief structural engineer, Holabird & Root, architects; **H. W. Lawson,** Bethlehem Steel Co.; **J. G. Shryock,** president and chief engineer, Belmont Iron Works; **Hale Sutherland,** professor of civil engineering, Lehigh University; **F. H. Frankland,** chief engineer, American Institute of Steel Construction (chairman).

News of the Industry

Design of Two Types of Welds Discussed

At a recent joint meeting of the American Welding Society and American Society For Metals, Worcester Chapter (Mass.), **Charles H. Jennings** of the Westinghouse Research Laboratories spoke on "Welded Design."

Mr. Jennings stated that the designer of a welded structure should be familiar with (a) the physical properties of the welded joints and parent metal, (b) the methods of calculating stresses in welded joints (c) working stresses and safety factors, (d) shop facilities and (e) methods of test.

There are two fundamental types of welds—the fillet weld and the butt weld. The fillet weld generally requires a minimum of plate preparation but because of its inherent design produces points of stress concentration. Proper weld design makes allowance for these stress concentrations.

Butt welds require more preparation but they produce fewer stress concentration points. They permit the use of large electrodes with a corresponding increase in welding speed and reduction in welding costs.

Mr. Jennings recommended the following rules for welding design:

1. Use minimum number of parts to reduce the amount of welding.
2. Do not make welds larger than necessary to carry the required loads.
3. Design around shop equipment to eliminate unnecessary expense in assembling and welding.
4. Use intermittent welds to reduce cost and distortion.
5. Avoid rigid joints.

» «

Convention Will Discuss Industrial Health—The 25th Annual Meeting of **The American Association of Industrial Physicians and Surgeons,** together with the first annual meeting of **The American Industrial Hygiene Association** will be held at Hotel Pennsylvania, New York City, June 4, 5, 6, and 7, 1940. This will be a four-day convention intensively devoted to problems of industrial health in all of their various medical, technical, and hygienic phases, with particular stress on prevention and control of occupational hazards.

» «

Wear Goggles Under Helmets for Maximum Eye Protection—Maximum eye protection at all times is assured for welders who wear safety goggles under their helmets, **American Optical Co.** declares, pointing out that when helmets are taken off or raised to do chipping or other close work the eyes are still protected. For additional protection, the company emphasizes that the goggles should have side shields and also lenses that are scientifically compounded to cut down glare, absorb heat, and resist impact of flying particles.

» «

Ohio State Will Hold 3-Day Welding Engineering Course

One year ago the Ohio State University established a four year curriculum in welding engineering to meet an apparent need for collegiate education in this field. The course draws together the basic sciences necessary in the training of an engineer for service involving the use of welding.

After inception of this course, the Welding Division of the Industrial Engineering Department discovered that there were many practicing engineers who needed, but lacked, basic training for welding engineering. The Division felt a distinct obligation to provide these men with an opportunity to get basic instruction in some of the fundamentals.

Accordingly, a special 3-day short course in welding engineering has been

TYPICAL BEAM DETAILS

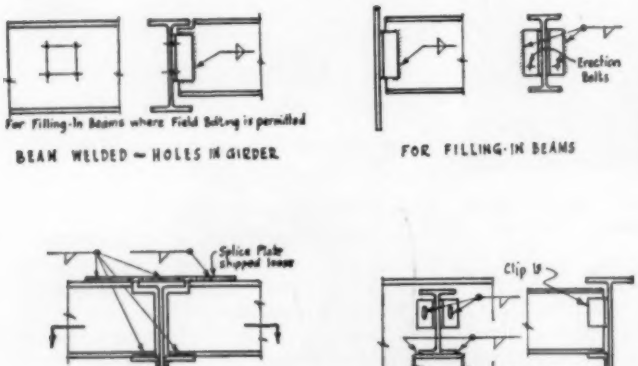


Fig. 5—Four typical welded beam details. Lower left shows how beam can be made continuous over top of girder.

Using a battery of arc welders to build highway bridge floor. Photo (General Electric Co.)

scheduled for April 16, 17 and 18. Three classes will be held daily on such subjects as: Welded Joints, Fundamental Mechanics, Welding Symbols, Production Welding, Etc. In the case of Welded Joints several classes will be devoted to this subject covering it progressively. Lectures will be given by prominent engineers as well as by members of the University staff.

This course will be given in place of the Annual Welding Conference which has been held on the campus each year since 1931. Information on this course is obtainable by writing to **J. R. Stitt,** assistant professor, Welding Engineering, Ohio State University, Columbus, Ohio.

» «

The Engineering Societies Library, 29 West 39th St., New York City, has broadened its services to the engineers of the world by making available at cost, not only photostats, but also microfilm copies of material contained in the 160,000 volumes and thousands of periodicals in its collection. Regardless of residence, any engineer, library, or company may order an 11x14-in. white-on-black (negative) photostat print on bromide paper at 30 cents each, which charge includes ordinary postage to any part of the world. Black-on-white (positive) prints are supplied by copying a negative print, which makes the cost 30 cents additional. Microfilm copies on 35-mm film are available at a cost of four cents per exposure (usually one page), with a minimum charge of $1.25 per volume.

For the benefit of those who can come to the library in person, a trained and courteous staff stands ready to assist them in their problems. Despite the fact that it is the official library of the four national engineering societies, all books and periodicals of the library are available for free use of the public during regular hours. If a translation or list of refernces on any particular subject is desired, the library staff will prepare it at cost.

» «

A.S.M.E. Has 60th Anniversary — Mechanical engineers throughout the United States and Canada are observing this month the Sixtieth Anniversary of the founding of their professional organization, **The American Society of Mechanical Engineers,** which today has 15,000 members, and maintains headquarters in New York City and 71 local sections in various industrial areas. The story of the growth of this Society coincides with the period in American industrial history in which the greatest mechanical developments have occurred, much of which have been made possible through the efforts of the A.S.M.E. and its members.

» «

Two Canadian Provinces Adopt A.S.M.E. Boiler Code—The provinces of Ontario and Manitoba in Canada recently passed orders-in-council providing for the adoption of several sections of the **A.S.M.E. Boiler Code** as part of their laws. Already adopted in the United States by 24 states, the Hawaiian Islands, Panama Canal Zone, and 18 municipalities, the Code, which has been prepared and is continually being revised in accordance with new developments in materials and methods by a committee of **The American Society of Mechanical Engineers,** provides a standard of safety in the design, construction, and operation of boilers and pressure vessels. Boiler explosions have become a rarity in those localities where the Code has been adopted.

» «

A.S.M.E. Spring Meeting in Milwaukee —A review of the latest developments in industry and engineering in the Midwest is to be covered in the many technical sessions scheduled for the 1940 Semi-Annual Meeting of **The American Society of Mechanical Engineers,** which is to be held in Milwaukee, Wis., June 17-20, with headquarters at the Hotel Pfister. Supplementing the engineering papers will be inspection trips to some of the outstanding manufacturing plants in the country which are located in and near Milwaukee. The city is particularly noted for the development of heavy machinery that can be found the world over in practically all fields of industry.

» «

Examinations for Appointment to Civil Engineers Corps, U. S. Navy

Examinations of candidates for appointment to the Civil Engineer Corps of the Navy have been authorized. The first will be a non-assembled examination for which candidates will submit their records in education and experience. Those found qualified for further examination may appear in Washington, D. C., in June, 1940 for physical and written professional examinations. To be eligible for these examinations candidates must be between the ages of 22 and 30 on April 1, 1940. They must be graduates in engineering of an approved college or university and must have had at least two years and eight months of engineering practice, on April 1, 1940, at least two years of which have been subsequent to graduation.

The written examination will last approximately four days and will pertain to such engineering subjects as are embraced in the practice of the Civil Engineer Corps of the Navy. The five receiving the highest marks in the examinations will be offered commissions in the Corps with the rank of Lieutenant (junior grade).

The Civil Engineer Corps of the Navy designs and constructs all public works of the Navy, such as Navy Yards, air stations, hospitals, magazines and radio stations, and these activities include buildings, dry docks, ship building ways, piers, quay walls, railroads, roads, water supply, sewage disposal, power and heating plants, and distributing systems. The maintenance of these structures is also to a large extent the responsibility of the Corps.

Further details and copies of the application form may be obtained by addressing the Chief of Bureau of Yards and Docks, Navy Department, Washington.

» «

Iowa State Welding Conference Was Very Well Attended

With more than 500 men, interested in learning more about new developments in welding practice, in attendance, Iowa State College, Ames, Iowa, held its Twelfth Annual Welding Conference, March 20-22, under the direction of **D. C. Faber,** Director, Engineering Extension Service. That Iowa welding men want to know about the best in welding technique was evidenced by their interest and attendance at the technical meetings, where 14 papers and discussions were presented during the three-day session. The morning and afternoon demonstrations by the welding equipment manufacturers held their continued interest where it was possible to see in actual operation the new developments on display and discuss with manufacturers' representatives new applications and talk over solutions of troublesome problems.

Diversion from the serious side of the meeting was provided by the banquet Thursday evening under the direction of **W. L. "Bill" Allan,** who set up a satisfying turkey dinner. **C. J. McGregor,** American Steel & Wire Chicago Manager, serving ably as toastmaster kept all on the edge of their chairs. "Mac" proved, if proof be needed, his ability as a raconteur with timely quips and some "ribs"—all this without referring to his well known little black book.

"Heinie" Schneiderwind maintained the spirit of hilarity with some good yarns and a bit of fun poking at the expense of some of his buddies. Those at the banquet will long remember "Heinie" as cool headed in time of emergency, when he ably ministered to **George Lloyd** who had a sudden attack of "mal de mer" or what

"Heinie" Schneiderwind is pondering just how to handle a couple of hecklers at the Iowa State welding confab. C. J. McGregor looks on admiringly.

Non-Ferrous Arc Welding

(Continued from page 28)

be heated to a blue heat, allowed to cool, and cleaned prior to welding. Any scarfing of the cast-iron to be welded with the Copper Arc electrode should be done by mechanical means, states the manufacturer.

Copper Arc electrodes may be used with a.-c. or d.-c. equipment and when used with d.-c. equipment, straight polarity, or electrode negative, is recommended for welding of cast-iron or steel. Current values recommended for Copper Arc electrodes will in general be the same as those for "Nico" electrodes. They will vary considerably according to thickness and character of base metal. Greater current values can be used with the Copper Arc than with "Nico" because of the low resistance of the copper core.

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was it? It is reported that some of the Balbach boys were tossing coins to see who got the territory that appeared to be suddenly without a crack salesman to cover it.

"Bill" Allan's well selected entertainment including the Jitterbugs, three tap dancing girls, a juggler of no mean ability and an emulator of Charlie McCarthy ended the banquet festivity.

» «

Weld-It-Yourself Idea Introduced in San Francisco

"Weld-it-yourself" is a new phrase on the lips of many a San Francisco craftsman. Four months ago **Eddie Husted** and **A. Neal Jacobs** started the **Build-It-Yourself Workshop** at 170 Otis St. Renting 20,000 sq. ft. in a loft building, they installed initially $5,000 worth of metalworking and wood-working machinery to be rented for short periods at reasonable fees.

From the first, the "weld-it-yourself" department proved to be one of the most popular. Here the welding fraternity commenced to gather. Some were experts who came merely to keep in practice; others were students who wanted to practice. Still others brought their own odd jobs to complete, or came to do the work furnished by professional and hobbyist boat-builders, machinists and metal workers in other departments of the shop.

In this unique shop the hobbyists as well as the professional metal workers may rent a workbench for $1.00 a week plus 15 cents an hour for the time actually spent in the shop. This fee includes a locker and free use of all hand tools. Power machinery, such as lathes, drill presses, sheet metal machinery and soldering equipment, rents for from 5 to 20 cents per quarter hour. Welding equipment rents at the same rate as power equipment, plus a small charge for rods and current or gas used. Each client has a shop time card, and the time the equipment is used is registered by a time clock.

Personals

H. E. Dralle Promoted—Appointment of **H. E. Dralle** as manager of the petroleum and chemical section of the Industry Engineering Department of Westinghouse Electric & Mfg. Co. is announced by **C. A. Powel,** manager of the department.

» «

Lukenweld Makes Several Organization Changes

Edward J. Charlton has been appointed general manager of **Lukenweld, Inc.,** Coatesville, Pa. Mr. Charlton has been a design engineer with Lukenweld since 1931. He was born in Philadelphia in 1907 where he attended high school and Drexel Institute of Technology. Before joining Lukenweld, Mr. Charlton was connected with Shephard-Niles Crane and Hoist Co.

Robert L. Bunting, who has been assistant shop superintendent since 1936, has been promoted to superintendent, succeeding **Roland J. Whiting,** resigned. Before joining Lukenweld in 1933, Mr. Bunting was associated with Cleveland Auto Co., Reliance Electric Motors and H. K. Ferguson Co., of Cleveland, Ohio.

George L. Snyder, who since 1937, has been assistant chief engineer of Lukenweld, has been promoted to chief engineer. Mr. Snyder was born in Rosemont, Pa., in 1912. He attended grammer and high school in Downingtown, Pa., and was graduated from Drexel Institute of Technology in 1935 with a B.S. degree in mechanical engineering. In the same year he joined the engineering department of Lukenweld.

D. Bruce Johnston, who has been engaged in experimental development and research work at Lukenweld since 1935, has been appointed manager of development and research.

Robert B. Nivison, who since 1939, has been night superintendent of Lukenweld, has been appointed chief inspector.

Other appointments include **Robert C. Sahlin** as assistant manager of sales, **S. Nelson Buell** as assistant chief engineer, **Fred W. Forbes** as assistant superintendent, **W. J. McAlpine** as general foreman and **George Wheatley** as methods engineer.

» «

George L. Gordon, who has been in charge of the New York office of Lukens Steel Co., has transferred to the company's main office at Coatesville, Pa., where he will engage in special sales work. **J. J. Reynolds,** who has been sales representative in the New York office of Lukens for the past 13 years, has been appointed manager of sales at New York.

» «

Claude J. Holslag, president and chief engineer of **Electric Arc Cutting and Welding Co.,** 152 Jelliff Ave., Newark, N. J., was acclaimed one of the "Pioneers of American Industry" at a special testimonial dinner on February 27th, held at the Waldorf-Astoria Hotel, New York City. Mr. Holslag's award was in "recognition of distinguished achievement in the field of science and invention." Mr. Holslag was also signally honored at a dinner held in Washington, D. C., on April 10th, in commemoration of the 150th anniversary of the founding of the United States Patent Office. His original a-c. transformer welder was exhibited at the Department of Commerce Auditorium, Washington, D. C., during the week of April 8-12.

» «

1939 Morehead Medal Awarded to Otto C. Voss

Otto C. Voss of Milwaukee, Wis., long-time authority on the oxy-acetylene process, received the **1939 James Turner Morehead Medal,** sponsored by the **International Acetylene Association.** The medal, awarded annually for outstanding work in production or utilization of calcium carbide and acetylene gas, was presented to Mr. Voss during the opening session of the 40th Annual Convention of the I.A.A. which was held April 10, 11 and 12 at the Schroeder Hotel in Milwaukee.

Mr. Voss, advisory superintendent of the tank and plate shop at the Allis-Chalmers plant in West Allis, Wis., became one of the earliest and most enthusiastic advocates of the oxy-acetylene process for both welding and cutting. He is nationally known for his constant leadership in the investigation, sponsorship and teaching of various metalworking techniques utilizing the oxy-acetylene flame. In recognition of these services, the inscription on this year's Morehead Medal states that the award is made to Mr. Voss for "continuous pioneering, untiring educational effort, and constructive sponsorship of oxy-acetylene process applications."

OTTO C. VOSS

In 1905 Mr. Voss became associated with the Allis-Chalmers Manufacturing Company, and since then he has guided many advances in metal-fabrication procedures developed and adopted by that organization. He is said to have installed

and used the first oxy-acetylene shape-cutting machine in the Middle West, and organized the production of shape-cut parts on a routine basis in the Allis-Chalmers plants. Some of the equipment first cut on the shape-cutting machine and welded by the oxy-acetylene process were plates for pressure vessels which are still in use after more than 30 years of service.

» «

Henry Booth, of New York City, **Ellsworth L. Mills,** of Chicago and **Philip Kearny,** of New York City were elected president, vice-president and treasurer respectively of **International Acetylene Association** for 1940. **H. F. Reinhard,** also of New York City, was re-elected secretary. The Association, pledged to foster the art and science of producing and using calcium carbide and acetylene, held its 40th annual convention in Milwaukee, Wis., during April 10-12.

Born and educated in Detroit, Mr. Booth began his vocational career as an employee of the Ford Motor Co. in that city. After the war he went to New York as a salesman for Canada Carbide Co. In 1920, the Shawinigan Products Corp., of New York was founded and Mr. Booth was appointed sales manager, a position he filled continuously until last month when he was elected vice-president. Mr. Booth resides in Westport, Conn., where he is president of the Westport Chamber of Commerce.

Mr. Mills is vice-president of The Bastian-Blessing Co., Chicago, manufacturers of "Rego" oxy-acetylene welding and cutting equipment. Mr. Kearny has been prominent in I.A.A. affairs for a number of years, having previously served as a director, vice-president, and president. He is founder and president of the K-G Welding and Cutting Co. of New York City.

Mr. Reinhard, who begins his ninth year as secretary, is associated with Union Carbide Co., New York City.

Trade News

Electrode Consumption Up 45%—Data released by N.E.M.A. indicates that welding electrode sales for the first two months of 1940 were 45% above the corresponding months of 1939. Following are the official statistics on sales volume: First two months of 1939....19,541,000 lbs. First two months of 1940....28,428,000 lbs.

These data are based on reports from 20 member companies. Shielded arc electrodes for ferrous welding constituted a major portion of the total sales for both periods of consumption.

» «

For Welder Training in Metropolitan New Jersey—The Welding Training Institute, opened April 1, 1940, at 23-25 Sussex Ave., Newark, N. J., has announced a system of instruction for welding operators, which has been developed to meet the varied requirements of industrial plants in the Northern New Jersey area. Courses for beginners are so arranged that students progress according to their individual abilities, rather than on a set schedule of hours, the completion of each unit of instruction being determined by proficiency tests. Advanced courses for experienced welders are planned individually, to correct faults in workmanship and to develop ability in the more difficult types of operation.

Also offered to experienced welders are special courses in low and high-pressure pipe welding, structural welding, aluminum welding, stainless steel welding, silver brazing, etc., and courses leading to qualification under various codes.

» «

The Westinghouse "Order of Merit," a recognition of distinguished service was conferred on 39 employees of Westinghouse Electric & Mfg. Co. during 1939, according to a recent summation of awards by the company's board of directors. More men received this medal and citation in 1939 than in any single year since inception of the Order in 1935. It has been conferred on 124 Westinghouse employees since that date.

» «

The Federal Machine and Welder Co. of Warren, Ohio, has just recently let a contract for a new engineering building with approximately 8,000 sq. ft. of floor space. Part of this building will be used for engineering offices and the balance for research and metallurgical laboratories. It is expected that the building will be completed, ready for occupancy, by May 15, 1940.

» «

The Dow Chemical Co., Midland, Mich., is expanding its rolling mill facilities to increase the production of Dowmetal. It is stated that the building and new equipment will entail an expenditure of nearly $500,000 and will step up production of Dowmetal in sheet form at least 50%. A new four-high rolling mill will be installed in a one-story factory type building, 300 ft. long and 100 ft. wide.

» «

First-Quarter Orders Up 12%—Orders received by **General Electric Co.** in the first quarter of 1940 amounted to $97,490,047, compared with $86,882,953 for the corresponding period in 1939, an increase of 12%.

» «

1940 National Metal Exposition—Floor plans for the 1940 National Metal Congress and Exposition have just been mailed to previous exhibitors, with requests for space selections. The Exposition will be held in Cleveland, Ohio, October 21-25, in that city's Public Auditorium. Former exhibitors are asked to make three choices of space locations. Upon receipt of space reservations the Assignment Committee of the American Society for Metals, sponsors of the National Metal Exposition, will make final allocations. The 1939 Metal Show attendance (held in Chicago) showed that over 90% of the registrations included presidents, vice-presidents, treasurers, engineers, purchasing agents, metallurgists, managers and superintendents of various companies.

» «

Westinghouse 1939 Orders Up 43% Over 1938—Incoming orders in 1939 reached the third highest level in the company's history, the Westinghouse Electric & Mfg. Co. announced in its annual report. Orders received during 1939 amounted to $214,239,044 compared with $149,662,776 in 1938, an increase of 43%. Net sales billed totalled $175,071,363 compared with $157,953,216 in 1938, an increase of 11%.

Net income for the year was $13,854,365 compared with $9,052,773 in 1938, an increase of 53%. Only 1929 and 1937 were better years. "It is impossible to determine how much of the improved business in 1939 was due to war abroad," said **G. H. Bucher,** president. "Undoubtedly business was stimulated by that cause. It is our hope and expectation that the country will be able to escape participation in war.

"We believe that good business will be maintained in the coming months, whether the war abroad continues or not. This viewpoint is shared by many business leaders and economists. A healthy sign is the widespread basis of the recovery, as indicated by sales. Our business in every line is better: improvement in industrial, central station, marine and other 'heavy industry' equipment is matched by similarly increased demand for refrigerators, electric ranges, lamps and other consumers' goods," said Mr. Bucher.

» «

Electric Arc Cutting & Welding Co. (Nu-Arc Welder Sales Division), 152 Jelliff Ave., Newark, N. J., has reorganized its method of distribution, effective April 1. Previously the a-c. welders made by this division were only sold direct to users by factory sales representatives. A new marketing plan for selling through regional jobbers and distributors has been worked out. Inquiries are solicited from prospective distributors of the Nu-Arc line.

» «

Harnischfeger Holds "Welding Clinic"—Developments in welding were examined in detail at a sales convention held March 1 and 2 by the **Harnischfeger Corp.** of Milwaukee, Wis. The two-day session of addresses and demonstrations of welding processes, technique, new equipment and sales methods was labeled a "welding clinic." Prefacing the meeting was "Harnischfeger Night," a reception tendered to the visitors by the faculty of Milwaukee School of Engineering. The next two days were occupied with discussions of a variety of welding applications.

Featured speakers were **K. L. Hansen,** the inventor of the P&H-Hansen welder, whose subject was "Circus Selling"; **F. A. Wilch,** who discussed welding sales methods; and **Mr. Miller** of Hartford Steam

Boiler Inspection & Insurance Co., who spoke on codes and welding specifications.

» «

"The Making and Shaping of Steel," is the newest motion picture depicting operations of **United States Steel Corp.**, subsidiaries. Film distribution centers have been established at subsidiary company offices in Pittsburgh, Chicago, New York, Birmingham, Cleveland and San Francisco. The new film tells the story of steel from the time ore is mined until the finished product leaves the mills. It is offered in seven reels (sound-on-film) and is available in either 16 or 35 mm. sizes. Each of the seven reels is complete in itself and may be used separately, although the use of the first two reels describing basic operations is recommended in combination with any of the other reels.

Technical societies, colleges, schools, civic and business organizations and others interested may obtain any of these films free of charge by application to the nearest distribution center.

» «

St. Paul Welding Clinic—On March 6, 7, and 8, 1940, **Nicols, Dean and Gregg,** dealers in iron, steel, heavy hardware, railroad, mine, mill, and automotive equipment, held their second annual welding show and clinic in their general office building at 8th and Sibley Sts., St. Paul, Minn. Registered attendance totaled 805.

Following manufacturers exhibited and demonstrated their full line of equipment:

Bastian-Blessing Co., Chicago, Ill., manufacturers of RegO line of welding and cutting equipment.

Marquette Manufacturing Co., Minneapolis, Minn., manufacturers of Marquette alternating-current arc welders.

Harnischfeger Corp., Milwaukee, Wis., manufacturers of P. & H. motor-generator arc welders.

Allen Electric Manufacturing Co., Kalamazoo, Mich., manufacturers of the Allen spot welder.

Schrader-Bowers Manufacturing Co., Mishawaka, Ind., manufacturers of the "Flame Shaper" flame-cutting machines.

John R. R. Miles, Inc., Prescott, Minn., manufacturers of Miles acetylene generators.

Chicago Steel & Wire Co., Chicago, Ill., manufacturers of Weldite welding rods.

A large corps of direct factory representatives, assisted by competent demonstrators and a large corps of **Nicols, Dean and Gregg** representatives cooperated to handle the demonstrations. A special feature of the show was the exhibition and demonstration of RegO Model KUX underwater cutting torch, demonstrations of which were conducted at scheduled hours during the three days of the show.

A complete complement of underwater cutting equipment was employed including oxygen and acetylene manifolding equipment and the RegO KUX four-hose model torch. Demonstrations were conducted in a large stock watering tank at depths down to 3 ft. Approximately 30 lineal ft. of cutting was done during the show. The piercing and cutting of heavy steel plate under water was witnessed by interested groups at each scheduled demonstration. The spectators were astonished at the speed with which holes were pierced in ⅝ in. and ¾ in. steel plate under water. It was demonstrated that this can be regularly accomplished within four seconds after the torch comes in contact with the metal.

A. W. S. Activities

Cleveland Section A.W.S.—This section will hold its annual welding conference during the afternoon and evening of May 3, 1940, at Hotel Statler. The following three papers are scheduled for presentation at the afternoon session (2:15 p.m.): "Flame Descaling, Cleaning, Dehydrating" by **George V. Slottman,** Air Reduction Sales Co. "Flame Hardening, Flame Softening, Flame Strengthening" by **J. H. Zimmerman,** Linde Air Products Co. "Economic Production of Heavy Mechanical Equipment by Use of Welding and Cutting" by **George Jessop,** S. Morgan Smith Co.

Following dinner at 6:30 p.m., the evening session will start at 8:00 p.m. with **Dr. J. C. Hodge,** research metallurgist of Babcock & Wilcox Co., presenting a paper on the "Metallurgy of Arc Welding." There will be a registration charge of 50c applying to those who attend either or both of the afternoon and evening sessions.

» «

Cleveland Section A.W.S.—At the regular monthly meeting held April 10 at the Cleveland Club, East 107th and Carnegie Sts., **William D. Halsey,** assistant chief engineer, boiler division, Hartford Steam Boiler Inspection and Insurance Co., spoke on the subject of "Welding Requirements of A.S.M.E. Power Boiler and Unfired Pressure Vessel Codes." Mr. Halsey also discussed the subject of "Welding Operator Qualification." He is chairman of the A.W.S. Committee on Standard Qualification Procedure.

» «

Detroit Section A.W.S.—**A. E. Gibson,** president, **The Wellman Engineering Co.,** Cleveland, Ohio, and a past president of A.W.S., presented a paper on "Effect of Design and Shop Tooling on the Cost of Welded Equipment" at the monthly meeting, April 9, held in the Colonial Room, Detroit-Leland Hotel. This was a joint meeting with the Association of Iron and Steel Engineers. Mr. Gibson emphasized that the greatest opportunities for cost reduction center upon designs which make possible large savings in production labor. He mentioned the bending of flat steel to reduce welding and also the premachining of parts before welding.

» «

Los Angeles Section A.W.S.—This section was treated to the rare distinction of hearing a technical paper presented by the most prominent woman in the welding engineering profession, **Miss Mabel M. Rockwell,** production research engineer for **Lockheed Aircraft Corp.** Miss Rockwell's paper was on the subject "Research and Development in the Aircraft Industry." Her paper included numerous references to the importance of welding in aircraft production.

» «

Philadelphia Section A.W.S.—"Fabrication of Pressure Vessels by Welding" was the subject of a paper by **M. Christensen,** engineer with **Babcock & Wilcox Co.** at the regular monthly meeting March 18, held at the Engineer's Club, 1317 Spruce St. From his wide practical experience in pressure vessel fabrication, the speaker selected several outstanding examples for special emphasis in his discussion of the subject.

» «

Pittsburgh Section A.W.S.—**L. C. Bibber,** welding engineer, **Carnegie-Illinois Steel Corp.,** spoke on the subject "Experimental Background of Welded Design" at the March 20 meeting held in the auditorium of Mellon Institute of Industrial Research, 4400 5th Ave., Pittsburgh, Pa. Mr. Bibber's lecture high-spotted his 15 years of experience, including results of his many large-scale tests conducted for the purpose of developing welded design standards.

» «

Oklahoma City Section A.W.S.—**Frank G. Flocke,** welding engineer, **The International Nickel Co.,** New York City, discussed "The Welding of Monel, Nickel, Inconel and Nickel-Clad Steel" at the regular March meeting, held Friday evening, March 1, at the Biltmore Hotel. A motion picture entitled "Modern Metalworking with the Oxy-Acetylene Flame" was presented prior to Mr. Flocke's paper. An honored guest of the evening was **George T. Horton,** president of the **Chicago Bridge & Iron Co.** and currently national president of the American Welding Society.

Current Reviews

"Fabrication of Large Equipment by Welding" by **L. S. McPhee,** welding superintendent, Whiting Corp., Harvey, Ill., was the subject of a technical paper in the April, 1940, issue of the A.W.S. Welding Journal. Mr. McPhee's paper covers engineering design, materials, equipment, preparation for welding and personnel of welding department.

» «

"Definitions of Welding Terms" is a report of an A.W.S. committee also appearing in the April, 1940, issue of the A.W.S. Journal. This report includes a master-chart of welding processes.

» «

Dictionary of Metals and Alloys—This new book, edited by **F. J. Camm,** contains descriptions of metals, their composition and physical properties, and special sections are devoted to electroplating, polishing, hardening and tempering, metal spraying, rust proofing, and useful data tables. Fluxes for soldering, compositions

Runner showing fractured and cracked blades which were repaired in 6 hours by Tobin Bronze repair-welding.

Repair-welding of fractured blade in power plant turbine completed in 6 hours

A SERIOUS SITUATION developed in Banff, Alberta, not long ago. It was discovered that a blade in one of the two turbines of the local power plant was fractured. To make matters worse, closer examination revealed that four other blades were badly cracked. The turbine was useless. To dismantle and make the repair meant a delay of at least two to three weeks. To replace the turbine meant an outlay of about $1,200 and a delay of from three to four months. For a while, it appeared as though Banff were in for a "blackout." Then, repair-welding was suggested.

Through a 14″ manhole, Mr. Jackson of Jackson Welding Shop, Calgary, welded the fractured and cracked blades in just 6 hours—actual welding required only 2½ hours; preparation, 3½. Only 4 lbs. of Tobin Bronze welding rod were needed to avert what might have been a serious situation.

This demonstration of the value of Tobin Bronze welding is typical of many which prove that Tobin Bronze is ideal for the general repair-welding of cast iron. The genuine is marked "Tobin Bronze Reg. U. S. Pat. Off." 60120

. . .

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Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

of soft solders and hard solders, melting points of various metals, and data tables on wire and sheet metal gauges are included. Published by **Chemical Publishing Co.**, 148 N. Lafayette St., New York City. Price of book is $3.00.

» «

1940 Index to A.S.T.M. Standards—The latest edition of "Index to A.S.T.M. Standards, Including Tentative Standards" gives information on all 885 standards as of January 1, 1940. The Index is of service to anyone wishing to find out whether the Society has issued standard specifications, test methods, or definitions covering a particular engineering material or subject and it is of help in locating the standards in the volumes where they appear.

All items are listed in the Index under appropriate key-words according to the particular subjects they cover. As a convenience a list is also given of specifications and tests in numerical sequence of their serial designations. Copies of this 152-page publication will be furnished without charge on written request to **A.S.T.M. Headquarters**, 260 S. Broad St., Philadelphia, Pa.

» «

Lincoln Electric Arc Welding Handbook Now in Sixth Edition

"Procedure Handbook of Arc Welding Design and Practice," sixth edition, just announced by **The Lincoln Electric Co.**, Cleveland, Ohio, contains 1125 pages and a total of 1557 illustrations, including photographs and drawings. The handbook is reissued to include all new data essential for efficient use of arc welding in all its varied applications. The new edition contains the results of two years of fact-finding by a staff of 200 arc welding application engineers.

Encyclopedic in scope, concisely written and well illustrated, the handbook is a complete arc welding reference guide. Written especially for use of designers, engineers, architects, production managers, welding supervisors and operators, the handbook contains a wealth of data of interest to engineers, designers, architects, draftsmen, steel fabricators and erectors, foremen, cost estimators, maintenance managers, shipbuilders, piping and pipeline contractors, job welders, welderies and repair shops.

The eight sections of the book cover the following subjects:

Part I—Welding Methods and Equipment (24 pages—23 illustrations).

Forge welding—thermit welding—Resistance welding—Gas welding—Atomic hydrogen welding—Arc welding—Metallic arc—Carbon Arc—Shielded Arc—Source of current supply—Characteristics of the welding generator—Transmission of welding current—Electrode holders—Electrodes—Protective equipment—Miscellaneous accessories.

Part 2—Technique of Welding (114 pages—167 illustrations).

Arc—Arc Length—Arc Blow—Preparation of work—Welding terms—Types of joints—Selection of joint—Location of Weld—Classification of Welds—Weld Symbols, etc.

Part 3—Procedures, Speeds and Costs for Welding Mild Steel (118 pages—143 illustrations).

Manual welding with bare or washed electrodes—Manual welding with shielded arc, all types of joints—How to estimate costs of welds made manually with shielded arc, etc.

Part 4—Structure and Properties of Weld Metal (28 pages—42 illustrations).

Part 5—Weldability of Metals (92 pages—92 illustrations).

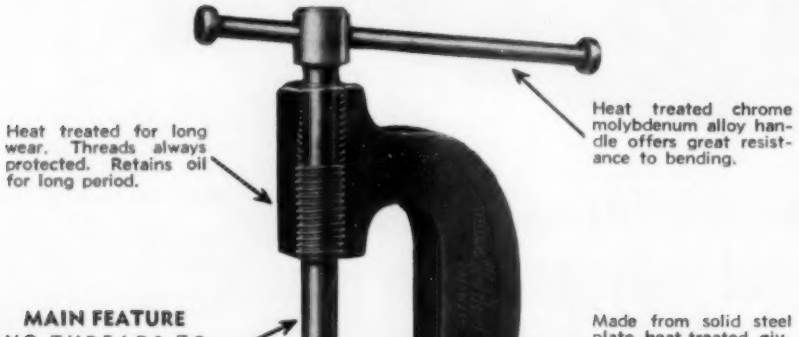
Factors affecting weldability—Why some steels weld better than others—Specifications for steels of good weldability—Procedures for 28 metals and alloys including: High-tensile steels, chrome-molybdenum steel, chrome-nickel steel, chrome-nickel clad-steel, 4-6 chrome steel, high-manganese steel, high-carbon steel, cast-iron, cast-steel, malleable iron, wrought iron, forgings, copper, Everdur, bronzes, brass, aluminum, Monel metal, nickel—A.W.S. specifications for filler metal.

Part 6—Designing for Arc Welded Steel Construction of Machinery (144 pages—252 illustrations).

Part 7—Designing for Arc Welded Structures (240 pages—301 illustrations).

Part 8—Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance (329 pages—537 illustrations).

"Red Head"
WELDING CLAMPS
Withstands All Welding and Handling Abuses


Heat treated for long wear. Threads always protected. Retains oil for long period.
Heat treated chrome molybdenum alloy handle offers great resistance to bending.
MAIN FEATURE
NO THREADS TO DAMAGE IN OPEN OR CLOSED POSITION.
WELD SPATTER EASILY REMOVED.
Made from solid steel plate, heat treated, giving great resistance to bending or twisting.
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14 STOCK SIZES

Special Sizes and Shapes Furnished for Special Applications

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Red Head Welding Clamps have been especially designed for welding service. Their construction eliminates the trouble caused by weld spatter or accidental damage to threads. A clamp that will stand up under the most rigorous service over long periods of time.

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The Procedure Handbook is 5¾ in. x 9 in. Binding is dark blue semi-flexible "simulated leather." Copies will be mailed, postpaid, to any address in the United States for $1.50 per copy; outside U.S.A., $2.00 per copy.

Recent Patents

Portable Spot-Welder

2,190,692. **William T. Bitler, John R. Bower,** and **Ray P. McBride,** Berwick, Pa., assigned to **American Car and Foundry Co.,** New York. Filed Sept. 6, 1935. Issued Feb. 20, 1940. Universal movement of a spot-welder is obtained, according to this patent, by mounting electrode jaws pivotally on a frame to provide for movement on a substantially horizontal axis, the frame, itself, being mounted on a supporting truck for rotation about a substantially vertical axis.

» «

Electrode Movement

2,190,927. **Harry E. Kennedy,** Berkeley, Calif., assigned to **Linde Air Products Co.,** of Ohio. Filed May 14, 1937. Issued Feb. 20, 1940. In submerged welding procedure, that is welding below a layer of finely divided welding material, it is impossible to observe visually the distance between end of weld rod and work. Accordingly, automatic feed must be used to advance the rod. The inventor has designed an automatic feed for feeding the rod in one direction at a rate of advance equalling the rate of consumption of the rod. The apparatus includes a casting having a passage extending axially therethrough. The casing receives a welding rod. A reciprocable one-way clutch is mounted on the casing and is adapted to engage the welding rod on alternate strokes to advance the rod in one direction. An annular expansion chamber in the casing is operatively associated with the clutch and operates the clutch by means of alternating inflation and deflation in the expansion chamber.

» «

Blowpipe

2,191,078. **Robert Kehl,** Manhasset, N. Y., assigned to **Linde Air Products Co.,** of Ohio. Filed March 31, 1937. Issued Feb. 20, 1940. For the purpose of preventing popping and soot deposition in blowpipe passages, the patent provides for sequential operation of auxiliary valves situated between the main gas valves and mixing chamber. If the auxiliary valves are closed simultaneously, popping takes place. In addition there is a formation of objectionable soot in the gas mixing chamber. Operation of the valves is accomplished by means of a suitable lever attached to the blowpipe handle.

» «

Metal Deposition Control

2,191,471. **Robert Hopkins,** New York, N. Y., assigned to **The M. W. Kellogg Co.,** New York, N. Y. Filed Sept. 16, 1936. Issued Feb. 27, 1940. To avoid the high cost of manufacture of electrodes of specific ingredients, and to more readily obtain deposition in desired proportion of any weld metal, the inventor uses as an electrode a hollow metal electrode through which metal can be fed to the welding zone. The hollow electrode is made up of one or more metals which form part of the deposited metal. The remaining desired metals are fed through the elecetrode, the feeding being at a rate independent of the rate of feed of the electrode. By controlling the relation between the cross-sectional area of the metal of the hollow electrode and the rate of feed of metal through the electrode, as well as the rate of feed of the hollow electrode, any desired composition of weld metal may be obtained. A similar control may be obtained, it is pointed out, by using a solid electrode and feeding additional welding metal to the welding zone by means of a conveyor belt. Here, too, the rate of feed of the electrode and the added belt-fed metal may be controlled. The added metal may be fed in the form of granules, pallets, wire, and the like. The electrode may be bare or coated. The process appears to have particular utility in the welding of chromium alloys of high-aluminum content or of low carbon content.

» «

Non-Gassing Flux

2,191,473. **Harry Blumberg,** New York, N. Y., assigned to **The M. W. Kellogg Co.,** New York, N. Y. Filed Aug. 13, 1937.

TITAN Provides the Correct Alloy for Every Oxy-Acetylene Bronze-Welding Purpose

TITAN Alloys—doubly-deoxidized to protect against formation of gas and oxides—give the best results for all oxy-acetylene welding and brazing applications:

Penn Bronze—is a general purpose rod. It is low melting (1620° F.) and tins easily and uniformly on galvanized, malleable or wrought iron as well as steel, brass, bronze and any other non-leaded metal with a melting point above 1850° F. It makes tough high-strength welds of high ductility, immune to strain hardening and with great abrasion and corrosion resistance.

Titan Manganese Bronze—is used where both hard and tough welds are desired. Although this is a general purpose rod, it is especially recommended for cast iron. It is free flowing and gives extremely dense, non-porous welds.

Titan Bronze—is a tin bronze with uses and characteristics similar to the manganese alloy; penetrates seams and crevices readily.

TITAN METAL MANUFACTURING CO., BELLEFONTE, PA.

TITAN BRONZE WELDING ALLOYS

Issued Feb. 27, 1940. A satisfactory flux for welding carbon steels and alloy steels must not only be non-gassing, but it must also have a minimum tendency to oxidize or promote oxidation. The patent describes a suitable flux for submerged welding operations. The composition contains calcium and magnesium silicates and calcium oxide. The calcium silicate is present in the form of ortho-silicates. The ortho-silicates render the composition self-disintegrating so that upon cooling, after being fused or highly heated, it will disintegrate itself into a powder. Such disintegration minimizes the need of grinding the completed weld. The completed weld is non-porous and smooth.

» «

Hollow Electrode Welding

2,191,476. **Robert Hopkins**, assigned to **The M. W. Kellogg Co.**, New York, N. Y. Filed May 21, 1938. Issued Feb. 27, 1940. To carry out the method of patent No. 2,191,471, an apparatus is provided which forms a hollow electrode from strip metal. The forming unit also serves to feed the electrode toward the workpiece. Welding metal is fed independently through the electrode to the workpiece. The device is stated to be useful for fabricating metal vessels, such as tanks, processing towers, and the like employed in the chemical industries. Fusion welding of the lining to the base metal of such vessels is readily accomplished with the new patented welding apparatus.

» «

Stud Welder

2,191,498. **Edward F. Nelson**, Vallego, Calif. Filed July 5, 1938. Issued Feb. 27, 1940. The patentee has designed a portable apparatus for electrically butt-welding studs to the surfaces of metallic objects. The machine electrically times the preheating of the parts to be joined so that all welds will be uniformly alike. The studs are placed and welded rapidly.

» «

Portable Spot Welder

2,191,912. **Albert D. Jardine** and **Harry Beronius**, Detroit, Mich. Filed March 5, 1937. Issued Feb. 27, 1940. Conventional transformer and welding units are supported on a beam in counterpoise relation to balance each other. This arrangement of the two parts provides for flexibility in movement of welding elements. A single beam supports both units, the transformer being movable at one end of the beam and along the beam, while the welding device is carried by a pulley suspended from the other end of the beam. Between the welding unit and transformer the beam is connected pivotally to an overhead T-beam upon which the entire apparatus can be moved horizontally. The intermediate pivot connection permits the transformer and the welding device to be swiveled around the connection as an axis.

» «

Wide Flame Blowpipe

2,193,100. **Homer W. Jones**, Westfield, N. J., assigned to **The Linde Air Products Co.**, of Ohio. Filed Aug. 24, 1937. Issued March 12, 1940. A wide flame, as well as a wide jet of cooling fluid, may be obtained by means of slots suitably situated in a blowpipe head. The elongated jet has an equalized velocity front. While employing such a wide jet for heating a welding zone, the pipe is adapted to direct a wide jet of a fluid, such as water, adjacent to the metal upon which the welding flame is being directed. By this device it is possible to effectively weld thick metal bodies to thin ones, as the cooling jet will prevent the thin metal from becoming overheated. The slots are formed by combining a pair of blocks, a gasket being disposed between the blocks. A slot-like opening forms a relatively wide and thin passage from a chamber formed between the blocks by hollowed out portions of the block faces which oppose each other.

» «

Electric Welder

2,193,490. **Frank H. Rehse**, Dayton, Ohio. Filed Aug. 13, 1936. Issued March 12, 1940. An electric welding machine which has a rotary member, one or more electrodes carried by and movable in a plane normal to the axis of rotation of the rotary member, and a common actuating means for the electrode or electrodes to bring them into engagement with the work and for thereafter rotating the rotary member. Both pieces of work, such as pipe of large cross section, are rotated in unison to obtain an average uniform length of current path through the different portions of the work pieces.

» «

Rail Joints

2,193,726. **Paul C. Jones**, Niagara Falls, N. Y., assigned to **The Oxweld Railroad Service Co.**, of Delaware. Filed Sept. 10, 1936. Issued March 12, 1940. A firm union between two rail ends is obtained, according to this patent, by providing channels beneath the ends of the rails and having shoulders which extend a substantial distance above the base of the rails. The shoulders carry a number of slots into which are fitted supports for the heads of the rails. The supports are welded to the shoulders at points spaced from the heads and webs of the rails. Such welding prevents overheating or objectionable metallurgical changes in the rail, which are said to take place if the rail itself is welded.

» «

Welding Flux

2,194,200. **Willi M. Cohn**, Berkeley, Calif., assigned to **Western Pipe & Steel Co.**, of Berkeley, Calif. Filed Dec. 13, 1938. Issued March 19, 1940. This invention is concerned with an aluminous flux for deep flux bed electric arc welding. The flux contains a powdered material having a melting point substantially in excess of the melting point of steel, the material being predominantly combined silica and alumina present as anhydrous crystalline material, the remainder being substantially anhydrous and including free anhydrous crystalline silica. Titanium dioxide and sodium fluoride may also be present. The flux, being a relatively poor heat conductor, forms a heat blanket which retains heat and properly anneals the weld.

» «

Welding Tubular Material

2,194,272. **Marshall A. Blu**, Chicago, Ill., assigned to **Sears, Roebuck and Co.**, Chicago, Ill. Filed Dec. 31, 1936. Issued March 19, 1940. It is customary to have the two parts of tubular material to be welded pressed together with considerable force so that the molten metal is squeezed out to form a bur. The bur has to be removed by grinding to present a smooth surface for painting. Such procedure is time consuming, expensive, and productive of weak welds in cases where

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11 to 13½% Manganese Nickel Steel

Special TITE-KOTE WELDING ELECTRODE

for A. C. and D. C. Welding

This newly-introduced electrode possesses a SPECIAL SELF-PEELING FLUX COATING that works equally well with A.C. and D.C. and in no way retards the quick cooling of the weld deposit.

Insures the same ductility and toughness found in deposits made with MANGANAL Bare Welding Electrodes. Weld deposits can be peened while hot without the danger of pounding slag into the weld metal.

Available in 1/4, 3/16, 5/32 and 1/8 in. sizes (14 in. length). Packed in 50-lb. containers.

Send for descriptive circular

STULZ-SICKLES CO. Sole Producers **91 N. J. Railroad Avenue, Newark, N. J.**

Manufacturers of MANGANAL Manganese Nickel Steel WEDGE and APPLICATOR BARS, Hot Rolled PLATES, etc. Illustrated circulars sent on request.

the grinding is too deep. The new method described by the patent provides the end of one tubular section with a peripheral flange. The side of the other tubular member is provided with a trough having an annular rib. The trough holds displaced metal when the two parts are welded, thus eliminating metal on the outer surface of the welded joint.

Trade Literature

"Silver-Brazing Alloys in the Marine Field"—Handy & Harman, 82 Fulton St., New York City, have just issued a reprint bulletin of an article which describes the applications of silver-alloy brazing in marine work. It is stated that since silver-alloy brazing in marine work applies with little or no variation to other work where these alloys are used, this article should be of interest to many readers. A copy can be secured by writing to Handy & Harman.

» «

Proper Care of Safety Goggles—To secure maximum results from safety goggles, they should first be worn and, secondarily, kept in perfect order. **American Optical Co.,** Southbridge, Mass., has evolved a set of simple rules on the care of safety goggles. These instructions, if followed, should assist in reducing goggle replacement and maintenance costs; at the same time, provide more efficient eye protection for workers. These rules have been published in the form of an attractive, well-illustrated bulletin, copies of which will be mailed on request.

Featured in the bulletin are proper methods of sterilizing goggles to avoid face and eye infection; also, instructions on proper goggle adjustment to avoid discomfort and "loopholes" for injuries.

» «

Republic Steel Corp., Cleveland, Ohio, has issued a new two-color, 40-page catalog on **Republic Double-Strength Steel,** a high-tensile, low-alloy product. Information is included on these subjects: How and Why the Product Was Developed; Resistance to Corrosion; Resistance to Fatigue; Fatigue Limits; Welding Qualities; Service Records; Fabrication, incorporating data on Cold and Hot Forming, Deep Drawing, Riveting, Machining, Gas Cutting, Gas and Electric Welding; Forms in Which the Material Is Available. Seventeen pages are devoted to photographs of outstanding applications in specific industries.

The book should prove helpful to designers, engineers and fabricators interested in use of high-tensile, low-alloy steel. Requests for copies should be addressed to Advertising Division, Republic Steel Corp., Republic Building, Cleveland, Ohio. Ask for catalog on Republic Double Strength Steel, Form Adv. 353.

» «

"Wilson Arc Welding Electrodes," an illustrated 24-page booklet just issued by **Wilson Welder and Metals Co., Inc.,** New York City, has been prepared as a useful guide in helping to make quick, sure selections of proper electrodes for all classifications of welding work.

The booklet reviews the general description, application, procedure for use, and physical properties of Wilson electrodes for numerous and varied welding purposes. Discussed in this manner are the flat, vertical or overhead-welding of mild steel; single and multiple-pass all-position welding of mild steel; horizontal fillet and butt welding of mild steel; high-quality, high-speed, deep-groove welding of mild steel; general purpose, all-position welding with a-c. transformers; all-position welding of carbon-molybdenum and low-alloy high-tensile steels; and all-position welding of cast-iron. Suggestions are also offered regarding selection of proper electrodes for other types of welding.

The final section of the booklet is devoted to "Welding Symbols and Instructions for Their Use," as published by American Welding Society. Copies of this booklet, No. ADW-18, may be obtained by writing to **Wilson Welder and Metals Co., Inc.,** 60 East 42nd Street, New York City.

» «

New 132-Page Manual on Spun Heads—A comprehensive publication on the subject of spun heads for boilers, tanks, pressure vessels and other uses, a new, 132-page manual issued by **Lukens Steel Co.,** Coatesville, Pa., contains considerable

View in the Bridgeport Brass Company's modern rod and wire mill.

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